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CIVIL ENGINEERING

OCT 3 1934

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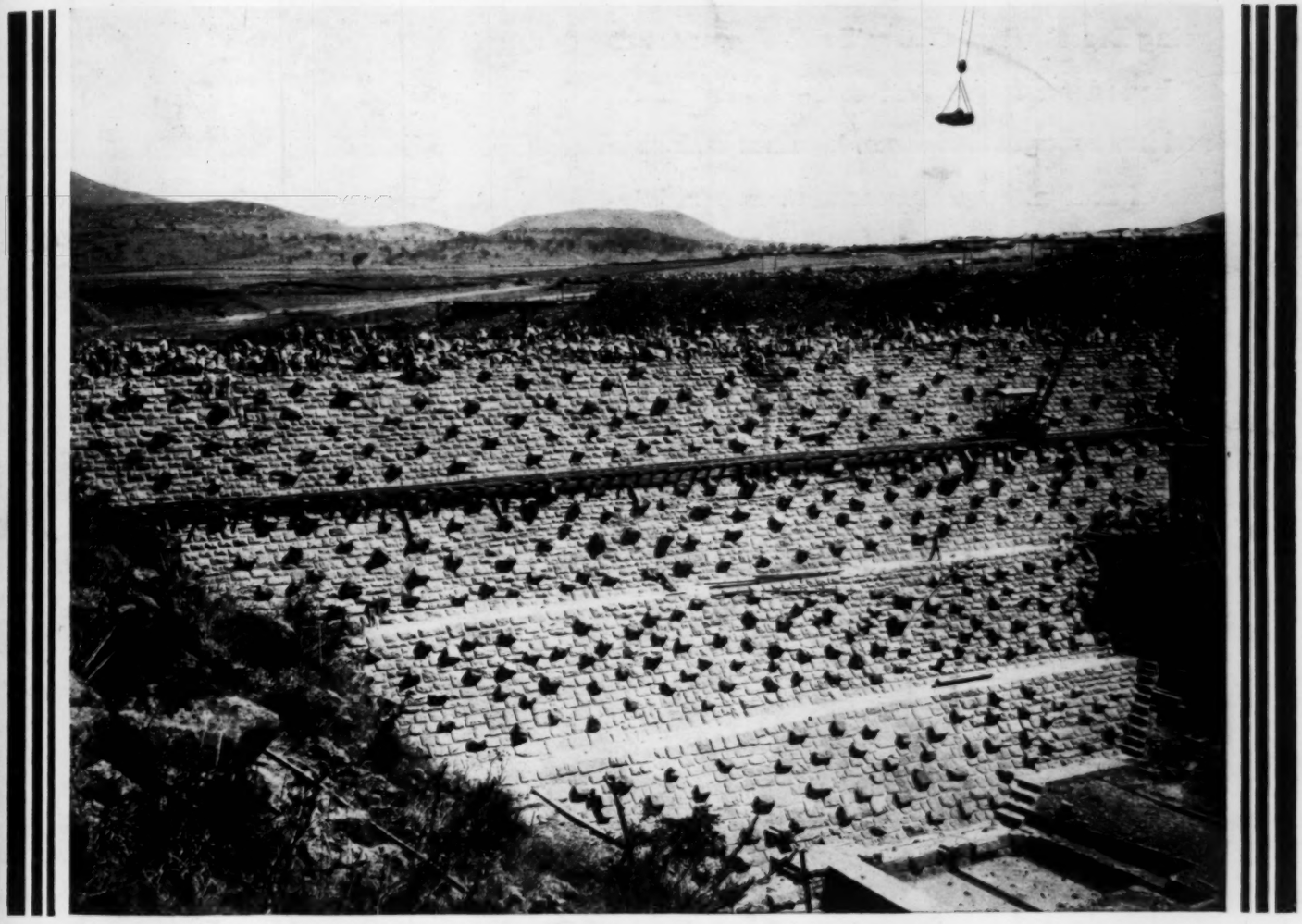
American Society of Civil Engineers



TEPUXTEPEC ROCK-FILL DAM ON LERMA RIVER, MEXICO, DURING CONSTRUCTION

Volume 4 — Number 10

AMERICAN SOCIETY OF CIVIL ENGINEERS FOUNDED 1852

OCTOBER 1934

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Among Our Writers

ROBINS FLEMING, at his retirement in 1931, had been with the American Bridge Company and one of its predecessors nearly fifty years. He has made many contributions to the technical press. Lafayette College, his alma mater, at its recent commencement conferred on him the degree of doctor of engineering.

E. W. LANE, a graduate of Purdue University, has been employed on a number of flood-control, navigation, and dam projects for public organizations and is now in charge of hydraulic and earth dam research for the U. S. Bureau of Reclamation. Readers will remember his articles on China in Volume I of CIVIL ENGINEERING.

F. B. CAMPBELL is a graduate of Cornell University. He has been employed by the U. S. Geological Survey and is now in charge of the earth material laboratory of the U. S. Bureau of Reclamation.

W. H. PRICE is a graduate of Tulane University and for the past four years has been in the employ of the U. S. Bureau of Reclamation on hydraulic and concrete research and on spillway design.

LLOYD F. RADER received the degrees of B.S.E. and M.S.E. in civil engineering from the University of Michigan. He has had experience in municipal and highway engineering in Indiana and as an engineer in the Pennsylvania and Nebraska state highway departments. He taught civil engineering for three years at the University of Nebraska, and since 1928 has been Assistant Professor of Civil Engineering in the Polytechnic Institute of Brooklyn, in charge of courses in highway and traffic engineering.

CLARENCE T. JOHNSTON, early in his professional career made a study of irrigation methods, laws, and administration. As state engineer of Wyoming, from 1903 to 1911, he aided in the recodification of the water laws of the state. Since 1911 he has been Professor of Geodesy and Surveying at the University of Michigan. Professor Johnston was among the first in Michigan to urge the registration of engineers.

H. E. M. STEVENSON was construction engineer for the Mexican Light and Power Company, Limited, from 1926 to 1930 on the Tepexic, Texcapa, Tenango, and Tepuxtepec projects. He was field engineer during 1930 for the City of Stockton, Calif., on the construction of the Hogan Dam on the Calaveras River; and during 1931, for the Sumner Sollitt Company of Texas on the construction of two roof weir dams on the Guadalupe River. He has since been employed as resident engineer by the Texas Highway Department. He is now in charge of construction of the Sims and Lampasas River bridges.

RICHARD S. KIRBY graduated from Yale in 1896. After a dozen years of practical experience, he taught civil engineering for four years at Gettysburg College. Since 1915 he has been in charge of engineering drawing at Yale, where he also teaches specification writing. As a hobby he studies and writes on automobile accident statistics and civil engineering history.

R. M. STROHL graduated in civil engineering from Ohio Northern University in 1908. After experience in the Philippine Islands, he became interested in highway construction in Ohio. From 1919 to 1923 he was associated with The Ludlow Engineers, Inc., Winston-Salem, N.C., and from 1923 to 1928 was designing engineer for the Carolina Engineering Company, at Charlotte, N.C., on municipal improvements. In 1929 he became assistant division engineer of the Ohio State Highway Department. At present he is engaged on design and construction of sewage disposal works with the A. H. Smith and Niles Company of Toledo, Ohio.

M. W. TORKELSON, following graduation at the University of Wisconsin in 1904, was employed successively by the U. S. Reclamation Service in Oregon, by the Inter-Oceanic Railway of Mexico at Jalapa, Vera Cruz, Mexico; by Ford, Bacon, and Davis in the reconstruction of the Memphis Street Railway; and by the Southern Railway as resident engineer on construction. In 1908 he became bridge engineer in the newly organized highway department of Wisconsin and in 1921, was made secretary of the Highway Commission, acting as deputy state highway engineer.

VOLUME 4 NUMBER 10

October 1934

Entered as second class matter September 23, 1930, at the Post Office at Easton, Pa., under the Act of August 24, 1912, and accepted for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized on July 5, 1918.

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Printed in the U. S. A.

CIVIL ENGINEERING

Published Monthly by the

AMERICAN SOCIETY OF CIVIL ENGINEERS
(Founded November 5, 1852)

PUBLICATION OFFICE: 20TH AND NORTHAMPTON STREETS, EASTON, PA.
EDITORIAL AND ADVERTISING DEPARTMENTS:
33 WEST 39TH STREET, NEW YORK

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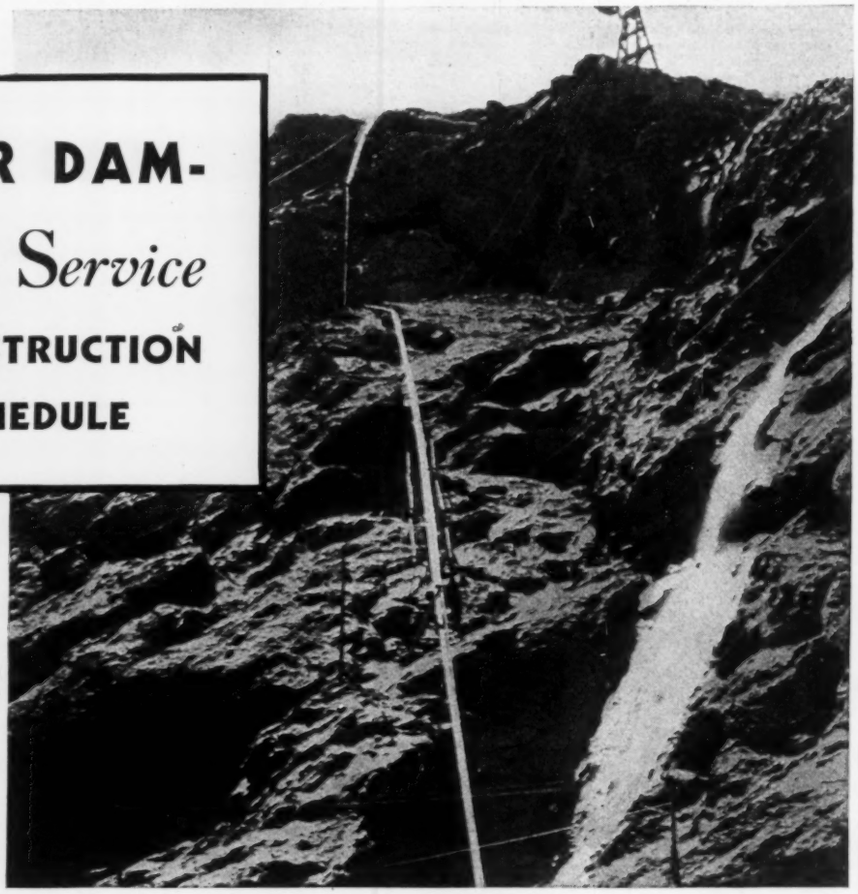

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CIVIL ENGINEERING

OCTOBER 1934

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VOLUME 4

NUMBER 10

Whence the Skyscraper?

Many Men and Numerous Concepts Preceded the Construction of the Home Insurance Building in 1884

By ROBINS FLEMING
AMERICAN BRIDGE COMPANY, NEW YORK, N.Y.

IF there is one structural accomplishment that is peculiarly American, it is the skyscraper. Even the name is of American origin. The year 1934 fittingly commemorates this great achievement, for it completes the 50-year period since the first skyscraper was begun. Nor could the antecedents of this wonderful development be better recounted than by Dr. Fleming. To a lifetime devoted to progress in structural engineering, he adds a keen historical sense. This paper describes the more important elements required as forerunners of the new type, such as the rolled beam, the elevator, flat-arch construction, and the isolated and spread footing. From these the skeleton-frame building grew. Many eminent men contributed, but to William L. Jenney is given the credit for faith exemplified in works—the notable Home Insurance Building of Chicago, started in 1884 and immediately becoming the progenitor of a new building age.

WHAT is a skyscraper? "Anything that extends high into the air, as a tall building," is the definition given in the *Standard Dictionary*. The great Murray *Dictionary of the English Language on Historical Principles* gives as one of several definitions, "a high building of many stories, especially one of those characteristic of American cities," and cites the *Boston Journal* (November 1891) as using the word for the first time. Evidently the term was in verbal use before that date.

Tall structures were built long before the era of the skyscraper, however. Rankine, in the first edition (1858) of his *Applied Mechanics*, describing "the great chimney" at St. Rollex, near Glasgow, built in 1841–1843 to a height of $435\frac{1}{2}$ ft above the ground line, writes, "It is, with the exception of the spire of Strasburg, the Great Pyramid, and the spire of St. Stephen's at Vienna, the most lofty building in the world."

The tourist in Edinburgh may read in his *Baedeker* that the Old Town is full of interesting houses, "some of which are remarkable for their immense height (10–12 stories)." *Modern Athens, Displayed in a Series of Views, or Edinburgh in the Nineteenth Century*, by Thomas H. Shepherd (London, 1929) is a book much prized by collectors on account of its engravings. Shepherd writes of these high houses:

"Previous to the commencement of the seventeenth century, owing to the price of building ground and the habit which the inhabitants of Edinburgh had acquired of living above each other in separate floors of the same house, it had been necessary to raise the buildings to a very dangerous height; it was, therefore, enacted by the Scottish Parliament in 1698 that no new house facing on a public street should exceed five stories, but as this law applied only to the front of a building, it not infrequently happened that from the inequality of ground the back part consists of eight, ten, or even more stories."

Cast-iron fronts were used so extensively in the United States during the fifties, sixties, and early seventies of the nineteenth century that they mark an era. The largest and most noticeable of these fronts was that of the A. T. Stewart (now John Wanamaker) store in New York, commenced in 1859 and rising 85 ft above the sidewalk. The store is five stories high and covers an entire block about 200 by 328 ft. The four fronts still face their respective streets in their pristine glory.

The framework of the Crystal Palace, erected on what is now Bryant Park in New York, was a wonderful combination of cast-iron columns, cast-iron beams, and wrought iron, although of the 1,800 tons of iron used in its construction, 1,500 tons were cast iron. The Palace was built to house the first World's Fair in the United States. It was formally opened July 14, 1853. The structure was not fireproof. On October 5, 1858, in less than an hour, it burned to the ground.

These illustrations may be regarded as approaches to the type of high structure we have today. Buildings had reached a limit of height before 1870. To build them higher it was necessary that easy access be provided to the upper stories. The passenger elevator was needed. In fact, for making the skeleton type of high building practical, we are mainly indebted to the following factors:

1. The rolled beam
2. The passenger elevator
3. Flat-arch floor construction
4. The isolated footing
5. The spread foundation

These will be considered briefly in the order named.

Beams of wrought iron were first rolled in the United States at Trenton, N.J., in 1854, and used for the first floor of the building in New York, N.Y., so long known as Cooper Union. The building was not completed until 1858. This was because the great printing estab-

lishment of Harper and Brothers burned to the ground on December 10, 1853, and the philanthropist, Peter Cooper, then principal owner of the Trenton Iron Works,

CHICAGO'S LARGEST OFFICE BUILDING

Forty-Two-Story Field Building Completed in 1933, on Site of Home Insurance Building. Photograph Courtesy of George A. Fuller Company, Contractors

generously postponed the rolling of beams for his own building in order to roll those needed for the new building of Harper and Brothers. In passing, it may be noted that the Harper plant, when finished, with its six stories above the ground floor and two stories below the street level, was the first fireproof building of any considerable magnitude. The cast-iron front was imposing.

About 1860 the Phoenix Iron Company began rolling iron I-beams. The first iron beams made in Pittsburgh were rolled on a 20-in. mill set up by Andrew Kloman in 1865. The rolling of steel beams marked another epoch in building construction. They are listed for the first time in the *Pocket Companion* of Carnegie, Phipps and Company, dated 1884. The preface to the edition of 1893 stated, "Our product hereafter will be exclusively steel." The age of steel had begun. Wide-flange "special" and "girder" I-beams made possible by the Grey universal beam mill were listed in *Structural Steel*, issued by the Bethlehem Steel Company in 1907. They had been rolled in Germany several years before being introduced in the United States by the Bethlehem Steel Company.

DEVELOPING THE PASSENGER ELEVATOR

As marking an epoch in building construction, the passenger elevator should be considered of equal importance with the rolled beam. Buildings of 7, 8, and 10 stories were thus made practicable, to say nothing of those of 20, 30, 40, and 50 stories, which came later. If skeleton steel-frame construction has made a superskyscraper possible, the rapidly moving passenger elevator has made it practicable. As some one has well observed, the elevator has figuratively turned the atmosphere into gold.

It is hard to resist the temptation to dwell at length upon the evolution of the elevator, but this is a subject in itself and will be left to the historian. The name of Otis is inseparably connected with it. Elisha Grave Otis gave an exhibit of a "contraption" at the Crystal Palace Exhibition in 1853. He died in 1861, but his interest and inventions were passed on to others. The first passenger elevator was built by Otis Tufts in 1859 for the old Fifth Avenue Hotel (a six-story building) in New York, at a cost of $25,000. A steam engine ran it by turning an immense vertical screw. It took the hotel guest no longer to reach his room by walking up the stairs than by taking the "vertical-screw railway," as it was called.

In the St. James Hotel, New York, the first suspended steam elevator of the Otis type was installed in 1866. The Equitable Life Assurance Company of New York was the first corporation to put up a great office building in connection with its own business. The work was carried on slowly and extended over several years. An elevator was installed in the first section built in 1868, and others in later sections. The building was destroyed by fire on January 9, 1912. In 1873 a water-balance elevator was placed in the Western Union Building and continued in service until the building was destroyed by fire in 1891. In 1878 the vertical-cylinder hydraulic type of elevator was introduced in New York City. It was but a few years until the hydraulic elevator had almost a monopoly of the field. When an electric elevator was installed in a building in Baltimore in 1887, it attracted little attention; yet in less than five years the electric elevator was competing with the hydraulic for speed in passenger service.

The elevator of today is a marvelous advance over that of only a few years ago. "It is almost human," as an operator of a recently installed elevator remarked to me as he was making an ascent, hardly conscious of speed. These modern elevators, although having operators in charge, eliminate most of the human control and substitute mechanical means.

FLAT-ARCH FLOORS INTRODUCED

The earliest form of fireproof floor construction consisted of brick arches sprung between wrought-iron floor beams and resting on their lower flanges. The lower flanges were not protected against fire. Steel begins to lose its strength at 600 F and at 1,000 F has little value in supporting loads. As it does not require a great fire to produce a temperature of 1,000 F, the importance of fireproofing is readily seen. Again, as buildings grew in height it became advisable to reduce the weight of the floor construction. Brick arches, leveled off with concrete, are heavy. Although they are the strongest type of arch for the span occupied, unless it be stone concrete, they are probably the most expensive. They long ago passed out of use except occasionally in buildings of the warehouse type.

Hollow tile as a building material was introduced in the United States in 1871, shortly after the Chicago fire. In his *History of Real Estate, Building, and Architecture in New York City* (1898), William J. Freyer writes:

"An American citizen, Balthaser Kreischer, a well-

known manufacturer of firebrick in New York City, invented and patented in 1871 the use of hollow tile flat arches between iron floor beams... It was in the U. S. Post Office in New York in 1872–1873 that for the first time in this or any other country were introduced hollow or flat tile arches between iron floor beams. In the same year, 1872, the Kreischer floor arches were placed in the Kendall Building, Chicago."

After long litigation, the Kreischer patent was declared void. The "end-construction" arch took the place of the "side-construction" arch in the early nineties.

As the engineer understands, the term "fireproof" is a misnomer. No building is absolutely fireproof. Louis de Coppet Berg, writing in the *Architectural Record* (Vol. 1, page 459) of the Metropolitan Opera House, New York, pronounced it "the first absolutely fireproof theater in the world." Yet, on August 27, 1892, only a few weeks after the publication of his article, the interior was destroyed by fire. The National Fire Protection Association recommends the discontinuance of the term "fireproof" and the use of "fire-resistive" instead.

ADVANCES IN DESIGN OF FOOTINGS

It was long the practice to make the foundation of heavy and important buildings one continuous bed of concrete or solid masonry. In the churches of Europe this bed was often built exceedingly thick, to resist the uneven reaction from the pier and wall loads. In the Government Post Office and Custom House in Chicago, constructed in 1877, the foundation bed was of concrete 3 ft 6 in. thick. The building settled so badly and so unevenly (24 in. in places) that after only 18 years of service it had to be replaced.

The method of designing each column and wall in a building to rest on its own foundation, independent of all others, was first advocated by Frederick Baumann, of Chicago. His pamphlet, *The Method of Constructing Foundations on Isolated Piers*, published in 1872, introduced a new principle in foundation construction. He laid down as one of the fundamental rules in designing foundations that they must be made to support their loads centrally. In his book, *Skyscrapers and the Men Who Made Them*, Colonel Starrett states that "Foundations are now a science; in 1880 they were a practice that had not advanced appreciably in thousands of years." The great advance that has changed a practice into a science is the isolated footing.

When carried into practice, the isolated footing gave the spread foundation. The pioneer example of this type of construction is the ten-story Montauk Block of Chicago, built in 1881–1882 after the plans of Daniel H. Burnham and John W. Root. Each pier of this structure rests on its own foundation. Under two stacks of fireproof vaults it was decided to embed iron rails in concrete footings to increase the allowable offsets in the concrete layers. This innovation constituted an important precedent, which gradually developed into the present grillage design. Soon I-beams were being used in the upper course in place of rails, and not long afterward they were used exclusively in the entire footing.

On both the isolated footing and the spread foundation the object is to have the area of the foundation bed so proportioned that settlement will be uniform. It was but a few years before footings on compressible soil were inadequate to carry the loads brought upon them by the constantly increasing height of buildings. Concrete caissons became necessary.

Soon after the appearance of passenger elevators, masonry buildings rose to new heights. Outstanding was the 16-story Monadnock Building in Chicago. This had, according to Starrett, the highest burden-bearing masonry walls ever built; at the basement

THE TACOMA BUILDING, CHICAGO, BUILT IN 1886–1887
Claimed by Some to Be the First Skyscraper

level they were nearly 15 ft thick. Interior masonry walls were replaced by iron columns and girders to save space. In accordance with modern terminology, however, the term skyscraper, as used in this paper, will be limited to tall buildings of skeleton construction. Skeleton construction is defined by the National Board of Fire Underwriters as:

"A form of building construction wherein all external and internal loads and stresses are transmitted to the foundation by a rigidly connected framework of metal or reinforced concrete. The enlosing walls are supported by girders at each story."

ORIGIN OF THE SKYSCRAPER

Who was the originator of the skyscraper? This question comes up periodically. As with many great inventions, the skyscraper as we have it today is not wholly the invention of any one man—it is an evolution. The names of Jenney, Burnham, Root, Holabird, Roche, Purdy, and Sullivan—all of Chicago—are inseparably connected with the early construction of high buildings. Starrett in his book says, "The great pioneers of the skyscraper were William Le Baron Jenney, Daniel H. Burnham, John W. Root, and William Holabird, pretty much in the order named. Other Chicagoans contributed, but these four were chiefs."

To William Le Baron Jenney is usually (and rightly) given the credit of being the real father of the modern tall building, or rather the form of skeleton construction that made it possible. The Home Insurance Building

of Chicago, as designed by him, is the first of all skyscrapers. It was begun in 1884 and finished in 1885. Originally it was of ten stories; two more were added in 1890. In 1931 the building was torn down.

William Le Baron Jenney was an engineer before he was an architect. He was born in Fairhaven, Mass.,

WORLD'S FIRST SKYSCRAPER—THE HOME INSURANCE BUILDING
Built in Chicago in 1884–1885 and Razed in 1931 to Make Way for the 42-Story Field Building

September 25, 1832. His father was the head of Jenney and Gibbs, a great whale-oil house. In 1849 he left Phillips Andover and in one of his father's whalers sailed by way of Cape Horn to join the rush of the "forty-niners" to California. Early in 1850 he arrived in San Francisco but remained there only three months before sailing for Manila, whence he returned home. While at Manila he became interested in the possibilities of the commercial development of Luzon, and according to his own words "decided to go home and study engineering," with the idea of returning and building railways across the island.

So he entered the Lawrence Scientific School at Cambridge, Mass., but not finding it to his satisfaction he went to France in 1853 and entered the École Centrale des Arts et Manufactures. While in Paris he became a friend of Whistler and Du Maurier. He returned to the United States in 1856 and shortly thereafter went to Tehuantepec as an engineer on the Tehuantepec Railway. In 1858 he returned to the United States and was engineer of the Bureau of American Securities until the outbreak of the Civil War, when he enlisted in the Engineer Corps. He was first sent to Cairo, Ill., to construct the forts there. Afterwards he was engineer at Forts Henry and Donaldson, at Shiloh, Corinth, and Vicksburg, and was with General Sherman on his march to the sea. In 1868 he started as engineer and architect in Chicago. His work as an architect includes a number of tall office buildings in Chicago as well as the Union League Club, Grace Church, and the Horticultural Building for the World's Columbian Exposition.

In 1896, F. W. Gates, the President of the Bessemer Steamship Company, having observed the immense advantage resulting to the iron trade from the introduction of iron buildings, announced that he intended to find their originator; and that if he could discover this benefactor of the world in general and the Bessemer Steamship Company in particular, he meant to name one of the company's steamships after him. The investigation brought on a controversy and was argued at considerable length in the technical press.

Besides Mr. Jenney, the major claimant to the honor was Leroy S. Buffington. He was born in Cincinnati, was educated there as a civil and mechanical engineer, and went to Minneapolis in 1873, where he died February 16, 1931. In 1880 he bought two volumes of a translation of Viollet Le Duc's discourses on architecture and from what he read began to make drawings and eventually evolved a plan for what he called a "cloudscraper," in which the masonry veneer was supported at each story on an iron shelf.

As the claim of Mr. Jenney is largely based on his work for the Home Insurance Building, it is of interest to note the developments as recounted by Mr. Jenney in the *Engineering Record* of July 11, 1896. His appointment for this work, made in the fall of 1883, laid stress

PROVING HOME INSURANCE BUILDING FIRST SKYSCRAPER
Member of Investigating Committee Points to Evidence Showing This Was First Building to Utilize Skeleton Construction

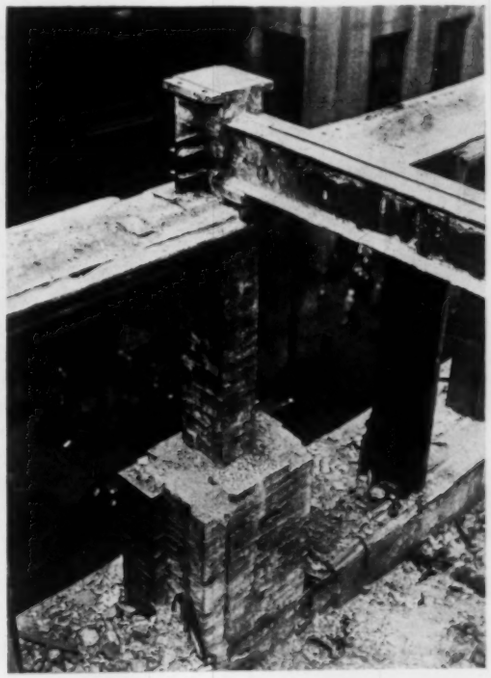
on the necessity for small, well-lighted offices, and hence for smaller and stronger piers than the then prevalent masonry construction. His solution was to utilize iron columns, with masonry protection.

Drawings were prepared, and the first design for a

fireproofed skeleton construction was presented to the Building Committee of the Home Insurance Company for their acceptance. As business men they naturally inquired, "Where is there such a building?" Mr. Jenney replied, "Your building in Chicago will be the first." This suggested to the company the very important question, "How do we know that it is good?" He proposed to submit his designs and calculations to one or more bridge engineers of distinction such as the company might select—the design for the skeleton building resembling in many respects an iron railroad bridge standing on end.

At this juncture General A. C. Ducat, one of the managers of the Western Department of the Home Insurance Company, claiming the floor and the privilege of making a speech, stated that he had been an engineer before he became an insurance man; that he had carefully studied the designs and the data for the calculations as presented by Mr. Jenney; and that they met his approval, both constructively and economically. He respectfully suggested that they be adopted and that the building should be commenced at the earliest date practicable. The motion was offered, seconded, and carried unanimously. Thus the building was commenced.

Outside Column Between Fourth and Fifth Floor Exposed



Head of a Column at Fifth Floor Level of Building

DETAILS OF SKELETON FRAME OF HOME INSURANCE BUILDING

Because he considered that he was only applying to a whole building the construction principles previously used for isolated columns, Mr. Jenney did not feel he should apply for any patent. On the other hand, Mr. Buffington claimed that he had put his ideas on paper as early as 1880 and that they had been printed in 1883. His application for a patent is dated November 14, 1887, and his Letters Patent No. 383170 are dated May 22, 1888, three years after the Home Insurance Building was finished. It was the intention of the Building Company to collect royalties, by suit, if necessary, from the owners of all skyscrapers in Chicago. Suits for infringement were actually instituted, and on them Mr. Buffington spent considerable money, although without collecting any damages.

CREDIT DUE TO JENNEY

Perhaps Starrett voices the preponderance of feeling when he remarks, "The fact is, regardless of his claim to prior invention, it was Mr. Jenney who put the problem to practical test, and to him belongs the credit, in spite of the commendable excursion of Mr. Buffington into the field of fancy."

In a concise yet comprehensive report, the committee appointed by the Western Society of Engineers to observe the wrecking of the Home Insurance Building in 1931 stated, in the Journal of that society dated February 1932, that it was not its province to determine which was the first steel building constructed, but rather to point out wherein the Home Insurance Building complies with or diverges from the essentials of a steel skeleton building (only the two front, or street, walls were considered).

"It is difficult for your committee," they wrote, "to conceive of the skeleton type of building being the invention of any one person, or the development of any one year, but rather the development of a period."

After stating the essentials of a steel skeleton building, they concluded:

"The Home Insurance Building was erected during the development period of the skeleton type of building and is a notable example of its type; while it does not fulfill all the requirements of a skeleton type, it was well along in this development and was principally lacking in not having curtain walls, no provision in the framing for wind loads, and not having made full provision for starting the masonry above the first floor."

Much has been written in arguing for the claims of this or that building as the earliest skyscraper. The 14-story Tacoma Building in Chicago, built in 1886–1887 and demolished in 1929, is claimed by some to be the first skyscraper. The 10-story "Tower Building" at 50 Broadway was the first skyscraper in New York, N.Y. A bronze tablet on the building stated that it was the first example of true skeleton construction and that it was "originated and devised by Bradford Lee Gilbert, architect." This statement has been vigorously opposed. Here again opinion in general agrees that the Home Insurance Building marked a new epoch in that it discarded the traditional bearing walls and embarked on a new, far-reaching innovation of skeleton construction. In this the fiftieth year since its erection, engineers may well pause and bestow a meed of credit and praise on it and on William Le Baron Jenney, in whose fertile brain it originated.

The Flow Net and the Electric Analogy

Devices for Studying Moving Water Used by the U. S. Bureau of Reclamation

By E. W. LANE, M. AM. SOC. C.E.,
F. B. CAMPBELL, JUN. AM. SOC. C.E.,
and W. H. PRICE

RESPECTIVELY RESEARCH ENGINEER, ASSISTANT ENGINEER, AND JUNIOR ENGINEER,
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FEW engineering subjects today are receiving the intensive study given to water in its various uses. Even among the spectacular feats of more monumental character, the experimentation described in this paper has outstanding value. The methods and apparatus are simple when one considers the complicated internal behavior of flowing water, and yet the results are striking in their prediction of flow as verified by test and experience. The flow net is shown to be a simple graphical adaptation singularly free from complicated details. Similarly, the electric analogy indicates by manipulation of an inexpensive laboratory apparatus flow lines and pressure lines not only in free flow but even under dam foundations and cut-off walls. To the authors goes the credit for ingeniously developing and perfecting their methods. Every hydraulic engineer should welcome this announcement of new tools made available to designers of American hydraulic structures.

IN the solution of some of the hydraulic problems of the Boulder Dam and of the Public Works projects carried out by the U. S. Bureau of Reclamation, two tools or methods, the flow net and the electric analogy, have been found very helpful and will doubtless be used extensively in the future. To some extent they have been employed previously in Europe for hydraulic work and in this country for certain problems outside the hydraulic field; but since hydraulic engineers in America do not seem to be generally acquainted with them, it is believed that the following account of their principles and application will be of value.

As applied to hydraulics, the flow net is a means of representing graphically the nature of the flow of water, which permits the accompanying velocities and pressures to be computed for many conditions heretofore usually determined by measurement on hydraulic models. In other words, it makes possible in the office the solution of certain problems which formerly could be solved only in the hydraulic laboratory. The electric analogy is a parallelism between the flow of water and the flow of electricity in a conductor of similar boundaries. By the use of this analogy, flow nets can be readily constructed for a great variety of simple and even complicated cases.

HISTORY AND THEORY OF THE FLOW NET

The original and mathematical theory of the flow net rests upon the foundation of differential calculus laid down by Newton 250 years ago. The equations of motion and of continuity are based upon the work of the great contemporaries, Euler, LaGrange, and Laplace, during the eighteenth century. Later Gauss, Stokes, William Thompson, Tait, Helmholtz, Maxwell, and a host of other mathematicians and physicists enriched our knowledge of the theory and its application.

The principles of the flow net have been used to solve a variety of problems. The magnetic fields surrounding the poles of an armature have been studied by this means, as described by A. D. Moore, in "Mapping Magnetic and Electrostatic Fields" (*Electrical Journal*, Vol. 23, No. 7, pages 336–362). The flow net was used by Hinderks for the investigation of pressure distribution in siphon spillways, as explained in his book, *Strömungs untersuchungen an Selbstätigen Saügüberfällen* (Hannover, 1928). The method was also employed at Hannover for the problem of flow under roller dams; H. Kulka records the results in an excellent treatise on the subject, *Der Eisenwasserbau*, Vol. 1. It seems first to have been introduced in this country by the late John R. Freeman, Hon. M. Am. Soc. C.E., in his summaries of these reports—*Hydraulic Laboratory Practice*, pages 605–618. Some work has been done with the flow net at the University of Iowa. It has been used extensively in studying the flow of water under dams by Forcheimer, Pavlovski, Leliavsky, Harza, Terzaghi, and others. As far as could be discovered, the first application of the electric analogy to the solution of hydraulic problems to be published was by N. N. Pavlovski, although H. B. Muckleston, M. Am. Soc. C.E., and the late E. E. Sands, Assoc. M. Am. Soc. C.E., used it many years ago to make laboratory investigations of the flow through earth-fill dams.

A more general conception of the flow net is sometimes called conformal representation. LaGrange studied the mathematics of this geometrical device and applied it to geographical maps. The mathematical theory is treated under the subject of conjugate functions. In conformal representation there are two families of curves; one set always intersects at right angles to the other. The geographical map offers a good example; the meridians represent one family and the parallels of latitude the other family. In two-dimensional hydraulic flow, one family of curves is called the stream lines, and the other,

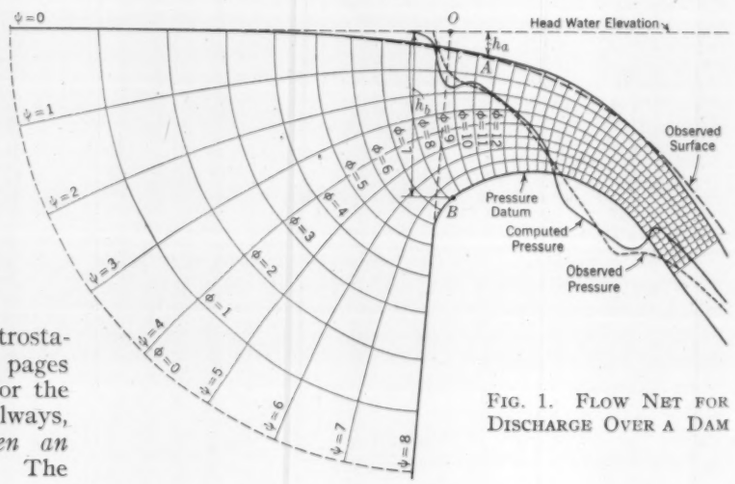


FIG. 1. FLOW NET FOR DISCHARGE OVER A DAM

the equipotential lines, or simply the "potential" lines. In the propagation of light and sound waves from a point source, the concentric spheres representing surfaces of equal intensity are one family, while the radial lines from the point source are the other family. Thus the general conception covers many fields of applied science. The theory of conjugate functions has long been used in electricity and is beginning to come into general use in the field of structures. Lines of equal rate of change of stress are studied by polarized light, by the slab analogy, and by the soap film analogy.

In this article, confined to the hydraulic flow net and the electric analogy, hydraulic nomenclature will be used. The stream lines are, briefly, the paths which the particles of flowing water trace. To consider only two dimensions, a strip bounded by two stream lines has the same flow at the intake end as at the outflow end. In numerical values the stream lines are conventionally represented by

$$\psi = \text{constant};$$

while the potential lines are usually represented as

$$\phi = \text{constant}.$$

When plotted on the same sheet the lines form a grid of curvilinear rectangles or, as a special case, curvilinear squares. The equations of continuity for the two families of curves are

$$\frac{\delta^2\psi}{\delta x^2} + \frac{\delta^2\psi}{\delta y^2} = 0; \text{ and } \frac{\delta^2\phi}{\delta x^2} + \frac{\delta^2\phi}{\delta y^2} = 0$$

where x and y are the rectilinear coordinates. These are known as the Laplacian equations and have many applications. By mathematical reasoning, it can be shown that the families of curves represented by ψ and ϕ intersect at right angles to each other. It can be further shown by a vector interpretation of Stoke's integral equation that the ratio of length to breadth of the curvilinear rectangles is a constant throughout the flow net. A paper on the mathematical theory by F. B. Campbell, is filed in the Engineering Societies Library in New York, N.Y.

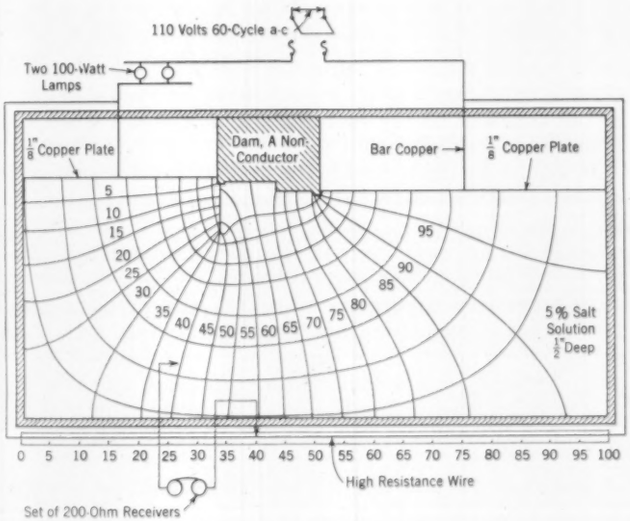
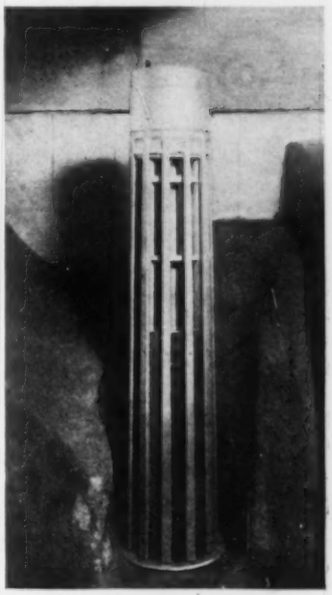


FIG. 2. ELECTRIC ANALOGY APPARATUS

SOLVING HYDRAULIC PROBLEMS WITH THE FLOW NET

Besides siphon spillways and roller dams, as already mentioned, the flow net can be applied to the solution of a variety of hydraulic problems. It has been used by the Bureau of Reclamation to determine the pressure on the crest of an overflow dam, as in Fig. 1, which shows a flow net developed by Clarence Rawhouser, Jun. Am. Soc. C.E., Junior Engineer, for one shape of overflow dam, and the pressures on the crest which he predicted by means of it. The observed piezometric pressure at any point is indicated by the height of the pressure lines above or below the crest at that point, heights above being positive pressures and those below, negative pressures. A model of the crest was also constructed, and the shape of the nappe and the pressures on the crest were observed. The agreement of the predicted and the observed results is very striking. Similar flow nets have been constructed to determine the pressures exerted on drum gates on a dam crest, to aid in their structural design.



HYDRAULIC MODEL OF COMPLETED GATE TOWER FOR BOULDER DAM

In addition, the flow net is useful in studying the flow of water under masonry dams on pervious foundations. For example, Fig. 2 shows a net constructed to show the flow under a dam on a homogeneous foundation material. By means of such a net the action of the water may be more clearly visualized. A series of tests is under way to study in a similar manner the flow through various types of earth dams.

GRAPHICAL CONSTRUCTION OF THE FLOW NET

A flow net may be constructed graphically by a rather laborious procedure, without resorting to the use of the electric analogy. Theoretically such a net might be employed in the solution of both two- and three-dimensional flows, but the complications introduced by the third dimension are so great that the graphically constructed net is practically limited to a two-dimensional analysis. An overflow dam, as shown on Fig. 1, is typical of the problems that can be solved by a two-dimensional analysis.

To construct such a flow net, the upstream face of the weir is projected upward to the intersection with the headwater level at point O. The potential line, $\phi = 0$, is then drawn from the upstream face of the weir to the water surface, as a segment of a circle with O as the center. Theoretically the radius should be infinite, but practically a radius two or three times the head is sufficient.

The flow net may be started from the potential line $\phi = 0$. The net can be made up of curvilinear rectangles, but the curvilinear squares are found most convenient. The line, $\phi = 0$, should be laid off in equal divisions. Later, it may be necessary to adjust these divisions. They are shown on Fig. 1 from $\psi = 0$ to $\psi = 8$. The net should be sketched roughly in its entirety from beginning to end. Much time can be wasted in attempting to perfect a single "square" or small group of "squares" before proceeding to the remainder. By a cut-and-try process the net is then adjusted until it meets the required conditions, namely, that the sides of

UPSTREAM FACE OF BOULDER DAM AND APPURTENANT WORKS AS SEEN FROM ARIZONA SIDE OF BLACK CANYON
On July 24, 1934, When Top Forms Were at Elevation 965 and Three of the Four Gate Towers Were Under Construction

each square are approximately equal and form approximate right angles at the intersections. In the case of water, rapidly accelerating in a curved path, the squares may be badly distorted. Since this adjustment process involves a great many changes in the position of the lines, heavy paper that will stand repeated erasures should be used. The speed with which a net can be sketched increases rapidly as one gains a little experience in the procedure.

If the boundaries of the flowing water are exactly known, the problem is greatly simplified. If not, they should be sketched in as accurately as possible and can be located more closely as the refinement proceeds. In working with the flow of water over weirs or dam crests, the classical experiments of Bazin will be found very useful in helping to establish the boundaries. These are described in "Recent Experiments on the Flow of Water Over Weirs," translated by A. Marichal and J. C. Trautwine, M. Am. Soc. C.E., in the *Proceedings* of the Engineers Club of Philadelphia, Vol. 9, pages 231–238, 1892, and Vol. 10, pages 136–164, 1893. Where the boundaries are not definitely located, certain known conditions aid in fixing them. For example, in the flow over a weir or dam crest, the velocity at any point in the free surfaces is equal to the velocity head corresponding to the distance of that point below the reservoir level; if the velocity of approach to the weir is large, the head corresponding to this velocity will of course have to be added to the reservoir level. By adjusting the net until the free surfaces at all points fulfill this condition, their position can be accurately located. In other words, these relations become a condition which the adjusted flow net must fulfill, in addition to the requirements necessary when the boundaries are definitely fixed.

In adjusting the net after the first trial, some engineers prefer to use diagonals that extend continuously through the squares. This diagonal net of curvilinear squares possesses the same properties of rectangularity and proportionality as the original net.

In order to compute the pressures at a certain point, two general principles are employed: first, the total energy at all points is the same and is composed of elevation, pressure, and velocity heads; second, the velocity at any point is inversely proportional to the length of the side of the curvilinear square at that point. It is necessary, therefore, first to establish the scalar value of velocity on the flow net. This can be done at the free water surface if its location is accurately known, since the velocity at any point, A, in the free water surface (Fig. 1) is that corresponding to its distance below the reservoir level. The velocities in all other points of the net can then be computed, since they are to the velocity at A in the inverse proportion that the sides of the squares at these two points are to each other. If the position of the free water surface is not accurately known, the velocity may be approximately established and refined as the adjustment to the known conditions is made by the cut-and-try process. The velocity can also be computed if the discharge is known, since equal discharges are included between each set of stream lines. If the discharge coefficients can be closely estimated, the velocities can also be accurately computed.

Having determined the scalar value of the velocity, the pressure P_b at any other point, B (Fig. 1), may be computed by the formula, $P_b = h_b - \frac{V_b^2}{2g}$. The head h_b is measured down from the reservoir elevation, and V_b can be computed from the distance between the points, ϕ_8, ψ_8, and ϕ_9, ψ_8, using the flow net for coordinate designations.

CONSTRUCTING A FLOW NET BY THE ELECTRIC ANALOGY

Flow nets, as developed by the electric analogy and as derived by the more laborious graphical method, are identical. The electric analogy apparatus may take many forms. One of the simplest is shown in Fig. 2, which was set up to study the flow through the soil beneath a structure acting as a dam. It consists of a shallow trough with plate-glass bottom and sides, provided with means for accurate leveling and filled to a depth of say $\frac{1}{2}$ in. with an electrolyte, usually a solution of common salt. At each side of this "dam" are placed $\frac{1}{8}$-in. copper plates at the position of the contact of the headwater and tailwater with the foundation material. These are connected to a 110-v alternating current through a lamp bank which reduces the voltage drop across the terminals to about 18 v. At the opposite side of the tray, over a meter scale, is a high resistance wire, 1 meter long, each end of which is connected to one of the terminals by a heavy copper wire. A spring at one end of this wire, not shown in Fig. 2, is necessary to keep it in tension under all conditions of temperature introduced by the current flowing through it. On this resistance wire a sliding contact connects through a set of earphones to a probing pencil.

In passing from one terminal plate to the other, the current follows paths, as shown by the light line connecting the terminals. Other lines crossing these represent lines of equal potential plotted for increments of 5 per cent of the total potential drop. The purpose of the apparatus is to determine these lines of equal potential. To locate any desired potential line, the sliding contact on the resistance wire is placed at the correct point and the probing pencil is moved around in the salt solution until the telephone receivers indicate that no current is flowing through the wire leading to the probing pencil. The position of this point is noted on coordinate paper, placed beneath the bottom of the plate-glass tray.

For example, suppose it is desired to find the position of the potential line representing a drop of potential from the "headwater" terminal of 40 per cent of the total drop between the terminals. The sliding contact is placed on the resistance wire at 40 per cent of its length, or 40 cm from the end connected to the "headwater" terminal (Fig. 2). Since the resistance of the heavy wires between the terminals and the ends of the resistance wire is negligible, and the resistance wire is uniform in cross section and resistivity, the resistance from the headwater terminal to the sliding contact is 40 per cent of the total resistance between terminals. Therefore the potential drop to this point is 40 per cent of the total potential drop. When the probing point, in moving through the salt solution, reaches a position where the hum in the receiver stops, this indicates that no current is flowing and that the potential at the probing point is the same as that at the contact point on the resistance wire, namely, 40 per cent of the potential drop. By determining the coordinates of several points of equal potential and joining them with a line, the position of the line of equal potential can be plotted. Obviously, if it is desired to determine the potential at any designated point in the salt solution, the probe is placed at this point and the sliding contact is moved until it reaches a point of equal potential, as indicated by absence of current through the receiver.

Experience with this apparatus has shown that potential lines can be located with a high degree of accuracy. To check it, an experiment was performed with the tray clear and the terminals entirely across each end. With this set-up, the potential lines for equal potential increments should be straight, equally spaced lines parallel to the terminals. The results obtained agreed very closely with the theoretical position.

Having obtained a complete set of potential lines, the flow lines could be drawn in graphically with little difficulty. They could, however, be constructed electrically by changing the terminals, making the dam and sheet piling of metal to form one terminal, and placing along the bottom and side edges of the tray a metal strip to form the other terminal, the former two terminals

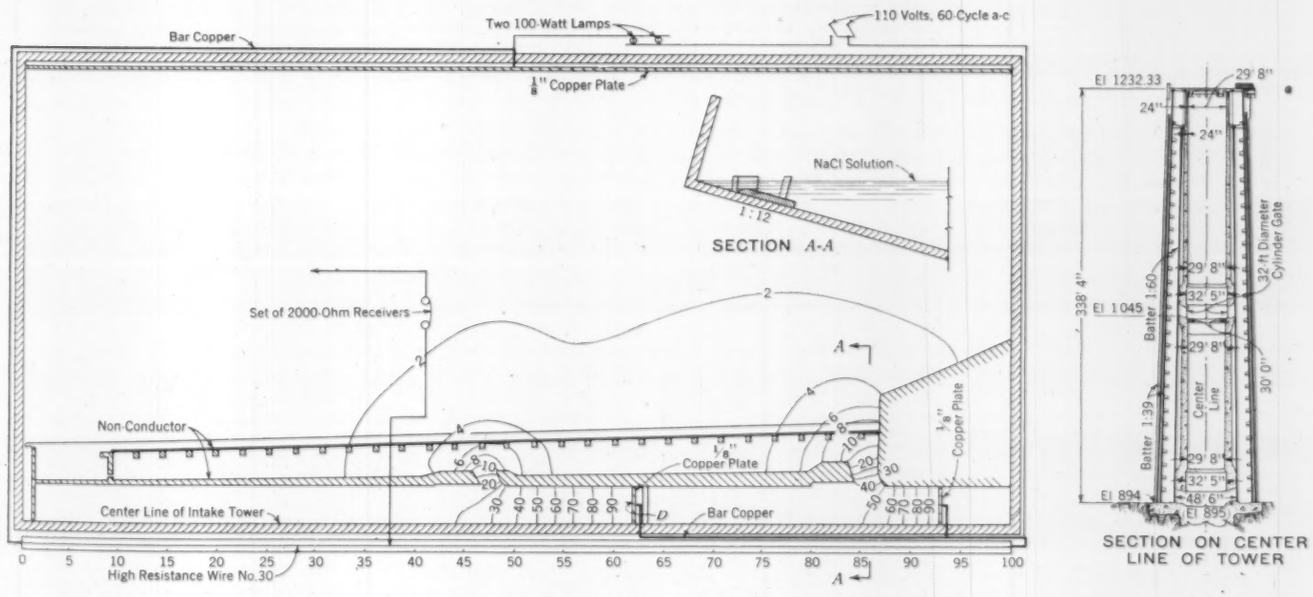


FIG. 3. STUDIES OF INTAKE TOWER FOR ELECTRIC ANALOGY MODEL

being replaced by a non-conductor. With these new terminals, the set of potential lines would be identical with the flow lines just obtained.

Many variations in the electrical set-up are possible. By using a longer resistance wire a higher voltage can be used, and this permits a more accurate location of the potential line. The voltage limit is that which will not permit sufficient current through the resistance wire to heat it unduly. The concentration of the electrolyte can be changed to reduce the current flowing through it to a reasonable amount. With vacuum-tube amplification, a loud speaker may be used instead of the telephone receiver. Sheets of very thin tinfoil have been used in place of the electrolyte. Their shape can be more easily altered than the shape of the electrolyte, but their resistance is so low that, in order to prevent heating, a very low voltage across the terminals must be used and a very sensitive detector is required. A pantographic mechanism arranged to plot the position of the probing point on a sheet of paper will materially reduce the labor of graphically presenting the results.

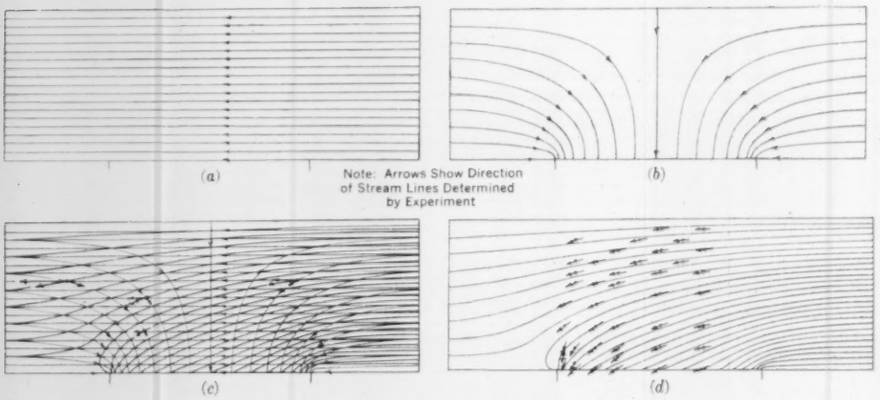


FIG. 4. METHOD OF COMBINING FLOW LINES

The electric analogy apparatus has several advantages over the graphical method in addition to the fact that it often permits a more rapid construction of the flow net. In the case of flow beneath dams, as illustrated by Fig. 2, it gives the pressures directly. Since the mathematical expression for the law of flow through an electrical conductor has the same form as that for the flow of water through soils at ordinary velocities, the drop in electrical potential in the analogy apparatus will represent directly the drop of piezometric pressure in the water flowing under the dam. Thus in Fig. 2 the potential lines can represent directly the percentage of the total piezometric drop from the headwater to the tailwater, as well as the percentage of the potential drop between the two electrical terminals.

One of the greatest advantages of the electrical analogy is that it permits a solution of problems in three dimensions. For example, in the design of the intake towers for Boulder Dam it was desired to determine the direction of the currents approaching the gate openings in order to reduce to a minimum the obstruction offered by the structure supporting the trash racks. No practical way was found to do this on a hydraulic model of reasonable size. A model of a sector of the tower and canyon wall was set up, with a salt solution representing the water space and a non-conductor representing the tower, (Fig. 3). The division of flow between the two gates, as determined by hydraulic experiment, was simulated by a corresponding division of the electrical current, secured by adjusting the position of the electrode, *D*. The potential lines shown on the figure were determined by means of the analogy. The direction of flow at any point is at a right angle to these lines. Other three-dimensional problems that can be attacked with the electrical analogy are the pressures beneath dams in a narrow canyon, or the effect of drainage holes beneath a dam in such a situation, and the flow of water around the abutments of dams on pervious foundations.

ANOTHER METHOD OF FLOW-NET CONSTRUCTION

A method of developing a flow net used by aerodynamic engineers is known as the method of sources and sinks. This is described by Leonard Barstow in *Applied Aerodynamics*, page 351. Its application to the problems of practical hydraulics is limited. In connection with it, however, there has been developed a method of combining flow nets which will be found to be valuable in the solution of certain problems. For example, the flow in a rectangular flume with a branch taking off at right angles may be analyzed as a combination of a flow straight down the flume, Fig. 4 (*a*), and a flow out of the branch, drawing water in both directions from the main flume, Fig. 4 (*b*). The directions of the water currents in the combined flow may be found by superimposing the two systems and joining the intersections of the stream lines of the two systems, as shown in Fig. 4 (*c*).

It will be seen that the direction of combined flow at any point is the resultant of the directions in the two simpler conditions. The agreement between the currents thus predicted and that actually observed for a case experimented upon at the Institution of Hydraulic Engineering in Vienna, as described by Mr. Freeman in his *Hydraulic Laboratory Practice*, page 428, is shown in Fig. 4 (*d*).

LIMITATIONS OF FLOW-NET SOLUTIONS SHOULD BE KEPT IN MIND

As applied to hydraulic problems, the theory of the flow net assumes the existence of a perfect fluid. This condition is hardly true of water, but in many cases the action is so nearly like that of a perfect fluid that no appreciable error is involved in the assumption. It can therefore not be applied where friction or impact losses are appreciable. Where water is accelerating, for example, as in flow over a weir or dam crest, through an orifice or under a gate, the flow-net analysis can be used with considerable accuracy, but where water is decelerating, impact or eddy losses are more likely to be set up and the results are apt to be less reliable. Flow through suddenly expanding sections, such as would be likely to cause eddies, could not be accurately analyzed. The accuracy of the agreement of the flow-net analysis with the flow of the water in the actual case will depend upon the closeness with which the flow of the water approaches the action of a perfect fluid. This should be kept in mind in deciding on the probable reliability of a flow-net analysis.

In the use by the Bureau of Reclamation of the flow net and electric analogy for the solution of hydraulic problems, assistance has been given by many persons, among whom are the following: R. E. Glover; Clarence Rawhouser, Jun. Am. Soc. C.E.; R. W. Powell, M. Am. Soc. C.E.; Ford Kurtz, M. Am. Soc. C.E.; and J. Danel.

The Law of the Road—Traffic Rights of Way

Court Decisions Pertaining to the Legal Rights of Vehicles and Pedestrians

By LLOYD F. RADER

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WITH more than 24 million motor vehicles in operation on the streets and highways of the nation and uncounted numbers of people playing the rôle of pedestrian, it is evident that a discussion of the legal rights of each type of traffic is of general interest. Violations of the "rules of the road" are the cause of many motor vehicle collisions. In establishing responsibility for injuries received in such accidents, it is usually necessary to determine which party had the legal right of way. Highway and traffic engineers have given the problem close study in the light of court decisions. In this article, Professor Rader has collected some of the most illuminating of these decisions relating to the legal rights of drivers and pedestrians and defining their respective rights of way.

CERTAIN rules regarding the legal rights of vehicles and pedestrians meeting and passing on public streets and highways have been established by long-standing custom or usage, and in many jurisdictions they have been extended and modified by statutory regulations and ordinances. These rules, regulations, and ordinances are commonly spoken of collectively as the "law of the road."

Many collisions occur under conditions which make it difficult to interpret the law of the road in order to determine which party had the right of way. As an illustration, consider the case shown in an accompanying photograph [below, at left] of two vehicles meeting at an intersection not controlled by sign, signal, or traffic officer, where one car is just entering the intersection and the other is already in it but not past the center line of the cross street. According to the following quotation, the car on the left (to the right in the photograph) has the right of way.

> In the absence of regulations to the contrary, the general rule is that the one reaching a street intersection first has the right of way. Elgin Dairy Company v. Shepherd, 108 N.E. 234, 109 N.E. 353, 183 Ind. 466.

Usually the right of way at uncontrolled intersections is given by statute to the vehicle to the right of the driver. For example, the statute in the State of New York provides that:

> Every driver of a vehicle approaching the intersection of a street or public road shall grant the right of way at such intersection to any vehicle approaching from his right. General Highway Traffic Law, Sec. 12, Subdivision 4, Consol. Laws, c. 70.

This might imply that in the case just mentioned the car on the right would have the right of way, but the New York court in Ward v. Clark (133 N.E. 443, 232 N.Y. 195) held that the statute "does not confer an inflexible and absolute privilege, since due regard must be had of the distance of each from the intersection and the speed of their approach." Ward v. Clark, 133 N.E. 443, 232 N.Y. 195.

The court, in the case of Barrett v. Alamite Dairy Company (181 N.W. 550), held that the law of the road does not require that a vehicle moving at a slow speed should stop to allow another to pass in front simply because it is moving at a faster speed.

In the Model Municipal Traffic Ordinance recommended by the National Conference on Street and Highway Safety, Section 014, page 42, the following rule is contained:

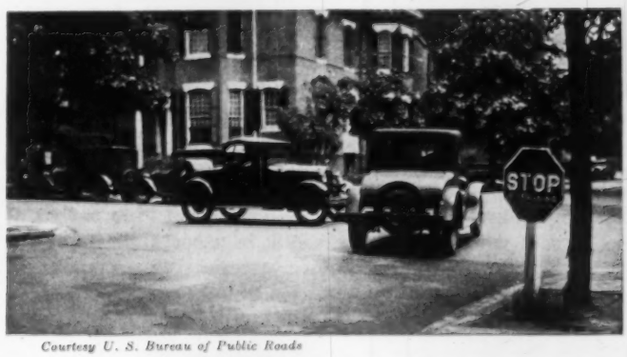
> (*a*) The operator of a vehicle approaching an intersection shall yield the right of way to a vehicle which has entered the intersection. When the two vehicles enter an intersection at the same time, the operator of the vehicle on the left shall yield the right of way to the vehicle on the right.

The following discussion of this rule is taken from *Regulation of Vehicle Operation on Highways*, published by the National Conference on Street and Highway Safety, page 15:

> The . . . wording is intended to give the section exactly the meaning which is usually given by the courts; namely, that the vehicle arriving first in the intersection shall have the right of way, that on the right having it if they arrive simultaneously.
>
> An important feature of the right-of-way rule is that it requires the one party to yield the right of way but does not authorize the other to take it. This wording leaves upon each operator the responsibility of avoiding a collision if possible.

Some municipalities have ordinances giving the right of way to vehicles on designated streets, and there are instances where no signs have been erected to give notice to vehicle drivers of such regulations. Some of the local

THE VEHICLE ENTERING A STREET INTERSECTION FIRST HAS THE RIGHT OF WAY



Courtesy U. S. Bureau of Public Roads

A THROUGH STREET IN WASHINGTON, D.C., PROTECTED BY A STOP SIGN

people may become familiar with such local ordinances, but it is unfair to apply them to drivers from other localities, who cannot be expected to know of their existence.

There has been difficulty in determining the right of way at intersections with through streets where the latter are protected by stop signs erected on the cross

CAR MAKING A RIGHT TURN ON A RED LIGHT INTERFERES WITH PEDESTRIANS CROSSING THE STREET

streets. For example, in the photograph [preceding page, at right], which car has the right of way, assuming that the car on the cross street has complied with the stop requirement? The following extract from the previously mentioned volume, *Regulation of Vehicle Operation on Highways*, page 16, considers this question:

> Two conflicting interpretations have been given to the through-street stop requirement. One is that the through traffic has an unqualified right of way on the through street, and vehicles on the cross streets may enter or cross only when they can do so without interfering with the through traffic. The other is that the operator on the cross street has discharged his duty when he has come to a complete stop and that he may then proceed with due regard for the traffic on the through street. The Model Municipal Traffic Ordinance accepts this latter view and contains a paragraph reading as follows:
>
> > The operator of any vehicle who has come to a full stop as required above, upon entering the through street, as well as operators of vehicles on such through street, shall be subject to the usual right-of-way rule prescribed by law and applicable to vehicles at intersections.
>
> Such a provision is believed desirable, as otherwise it is difficult or virtually impossible for vehicles to enter or cross through streets carrying heavy traffic.

RIGHTS OF PEDESTRIANS AT INTERSECTIONS

The question whether or not a pedestrian looked for approaching vehicles before attempting to cross a street at a crosswalk is an important one in determining contributory negligence on his part in case of an action for damages due to injury in collision with a vehicle. The courts have adopted two viewpoints in interpreting the common law that pedestrians and drivers of vehicles have equal and reciprocal rights. The first view is that a pedestrian who does not first look to ascertain whether a vehicle is approaching before attempting to cross a street is not negligent as a matter of law:

> There is no absolute rule of law that, to be in the exercise of due care, one about to cross a public street must look and listen for approaching vehicles. Hall v. Railway, 47 N.E. 124, 168 Mass. 461.

The second view holds that a pedestrian must look. Upholding this ruling is the leading case (Barker v. Savage, 45 N.Y. 191, 6 Am. Rep. 66):

> A wayfarer is not at liberty to close his eyes in crossing a city street. His duty is to use his eyes, and thus protect himself from danger.

In a later case, Knapp v. Barrett (110 N.E. 428, 216 N.Y. 226), the court ruled as follows:

> If the traveler may rely to some extent on the assumption that care will be taken by the driver, the driver may also rely to some extent on the assumption that care will be taken by the traveler.
>
> While the law does not say how often a pedestrian must look, nor how far, nor when, nor from where, if he looks as he starts to cross, and the way seems clear, he is not bound as a matter of law to look again.
>
> Where one is negligent by failing to look before crossing a city street, to escape the consequences of his negligence, he must prove that, even if he had looked, the accident would still have happened.

These opposite rulings were discussed by the Maine Court in Shaw v. Bolton (119, Atl. 801, 1923):

> There are authorities holding that a pedestrian who attempts to cross a street without looking is as a matter of law barred of recovery. Even under the doctrine of such cases when the pedestrian has once looked and found the way clear, he is not bound as a matter of law to look again. But the sounder and better doctrine is that stated in Hall v. Railway, supra. Whether pedestrians and motorists in exercising their mutual and equal rights on street crossings use due care is a matter of fact.

It might be stated that in the majority of cases questions of fact are left to the jury to decide.

RIGHT OF WAY AT CROSSWALKS

By the provisions of the Uniform Vehicle Code, Act IV, Uniform Act Regulating Traffic on Highways, the common law rule which accorded equal and reciprocal rights and duties to vehicle drivers and pedestrians has been altered. Statutes following this code accord the pedestrian the right of way when crossing a roadway on a marked crosswalk or at the usual place of crossing an intersection. In return for this preferential right the pedestrian is required to yield the right of way to vehicles at other points.

In the following Pennsylvania case, by statutory pro-

PEDESTRIANS SHOULD BE GIVEN THE RIGHT OF WAY AT CROSSWALKS ON A GREEN SIGNAL

visions the pedestrian had the right of way at the crosswalks of an uncontrolled intersection:

> At street crossings, automobilists must be highly vigilant, and maintain such control that on shortest possible notice they can

stop cars to prevent injury to pedestrians who have right to cross streets at crossings and rely on automobiles not to run them down. . . . Proper care at street crossings is the highest duty of motorists. Johnson v. French, 140 Atl. 133; Pa. 1928.

The Model Municipal Traffic Ordinance, Article IV, Section 16, states with respect to pedestrians' rights and duties at controlled intersections:

At intersections where traffic is controlled by traffic control signals or by police officers, operators of vehicles shall yield the right of way to pedestrians crossing or those who have started to cross the roadway on a green or "Go" signal, and in all other cases pedestrians shall yield the right of way to vehicles lawfully proceeding directly ahead on a green or "Go" signal.

One of the leading cases supporting this rule is Riddel v. Lyon, et al. (213 Pac. 487, 124 Wash. 146, 1923):

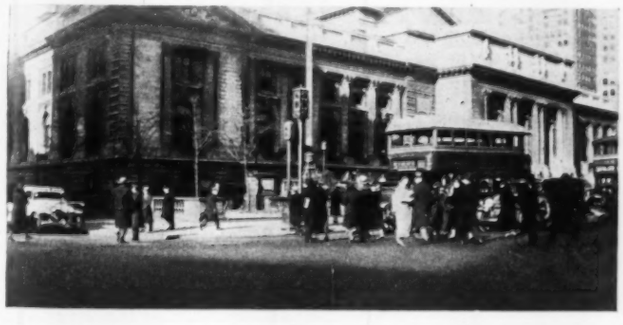
Under a city ordinance providing that at street intersections where a traffic officer is on duty, pedestrians shall cross the street with released traffic, and not otherwise, a pedestrian who starts across a street intersection when the signal permits is entitled to the right of way over vehicles crossing his course, though the signal was changed to release those vehicles before the pedestrian had reached the other side.

In the case of the Quaker City Cab Company v. Fixter (4 Federal Rep., 2d series, 326, 1925), the court also upheld this rule:

It is not negligence for a pedestrian to start across a street when the signal is against vehicle traffic thereon, though the signal may be changed before he reaches the other side and he has the right of way against a vehicle thereafter approaching, but he is chargeable with negligence if he starts against the signal.

RIGHT TURNS ON RED LIGHTS

It is the practice in some municipalities, as for example the city of New York, to grant vehicles the privilege of making right turns on a red light at intersections controlled by signals. This practice no doubt expedites vehicular movements, particularly where the signals are operated on a long cycle. Even though pedestrians are accorded the legal right of way over all vehicles when crossing at crosswalks on the green signal, drivers are prone to disregard the rights of pedestrians, and since so many vehicular movements in different directions are possible under this rule, pedestrians must be alert for their safety. An illustration [preceding page, left-hand column] shows pedestrians being prevented from



RED-HAND SIGNALS ON FIFTH AVENUE, NEW YORK, PROVIDE PERIODS FOR PEDESTRIANS TO CROSS THE STREET

crossing the street by a car making a right turn on a red light. Thus one of the main objects of signal control at intersections—namely, the protection of pedestrians—is not attained. The opinion of the National Conference on Street and Highway Safety was expressed as being opposed to this practice of permitting turns on red lights, except under special conditions where proper signs and signals are installed. A number of cities have attempted to provide better protection to pedestrians by instituting "pedestrian clearance intervals" in the operation of traffic control signals.

New York City has been experimenting with special

Courtesy U. S. Bureau of Public Roads

THOMAS CIRCLE AT 14TH AND MASSACHUSETTS AVENUE, N.W., WASHINGTON, D.C.

signals installed on Fifth Avenue between 40th and 45th streets. These signals have an illuminated red hand in place of the usual red light. It is claimed by their advocates that the hand has a beneficial psychological effect on motorists, tending to keep them from disregarding the signal and from starting off while the light is still red. In this system no turns are permitted on a red light. When the red hand and the amber light above it are illuminated on both streets, all vehicles are required to come to a complete stop. In this way a period is provided exclusively for pedestrian movement.

ROTARY TRAFFIC EMPLOYED AT MULTIPLE INTERSECTIONS

Another photograph shows the intersection at Thomas Circle in Washington, D.C., where traffic is controlled by rotary motion. This method has been frequently used at points where a number of streets converge. Traffic keeps to the right in passing around the central circle, and ordinarily no traffic signal is used. The cars tend to weave from the intersecting streets into the main stream of traffic. One advantage of rotary control is that it distributes the vehicles more uniformly over the roadway than the so-called "block" system, which employs traffic signals. Properly designed rotary intersections may be highly efficient from the standpoint of facilitating vehicular movement, but they do not provide adequate protection to pedestrians when vehicular traffic is heavy.

Right-of-way rules and the care required of motorists at rotary intersections are practically the same as for ordinary intersections not controlled by sign, signal, or traffic officer. Even if pedestrians have the legal right of way at regular crosswalks, the fact is that when vehicular traffic is heavy they find difficulty in asserting it without risk to themselves since it is dangerous for them to weave between the cars, even at a regular crosswalk. It would seem that an intersection controlled by signal or traffic officer, with designated periods for pedestrian movement, would provide better physical protection to them than the rotary type of control.

The crossing of streets by pedestrians at points other than crosswalks at intersections is quite common. The following statement of the Pennsylvania court is of interest in this connection:

A pedestrian using due care may cross a street between intersections, but when he does so he must exercise a higher degree of care than required at public crossings, and the fact that pedestrian crossed street other than at intersection does not necessarily convict him of contributory negligence. . . . Though a pedestrian is required to keep a lookout in crossing a street diagonally, it cannot be said as a matter of law that he must turn and look back. . . . The running down of a pedestrian by a taxicab when pedestrian is in plain sight and does not change his course is evidence of negligence. Robb v. Quaker City Cab Company, 129 Atl. 330, 1925.

PEDESTRIANS CROSSING BETWEEN INTERSECTIONS ON 42D STREET, NEW YORK, N.Y.

PEDESTRIAN CROSSINGS

Many cities have ordinances prohibiting pedestrians from crossing streets at points other than crosswalks at intersections. The rulings of the courts under this condition are of importance. In the case of Crowler v. West Coast Steel Company (186 Pac. 866, Wash., 1920), the court ruled as follows:

If the plaintiff, at the time of his injury, was crossing the street between intersections, he did so in violation of the ordinance we have quoted (Tacoma Ordinance No. 6626, Sec. 23, giving vehicles the right of way between intersections) and was guilty of negligence as a matter of law.

A pedestrian negligent as a matter of law in crossing a street between intersections should not necessarily be non-suited in an action for damages occasioned by being run down by an automobile, as it would still be for the jury to determine certain other features, such as whether his negligence contributed to his injury, or whether the defendant saw or should have seen him in time to have avoided the injury.

The following rule of law was stated in New York in 1923 in the case of Clark v. Doolittle (199 N.Y. Sec. 814):

The general rule in this state is that a violation of a statute or ordinance neither of itself constitutes or fixes liability for negligence, nor prevents recovery for an injury where the proximate cause was the negligence of another, but such violation is prima facie evidence of negligence.

In Winch v. Johnson (104 Atl. 81, N.J. Ct. Er., 1918), the court held that "the violation of the traffic law by the defendant was only one element to be left with the others to the jury."

Frequently a pedestrian steps suddenly in front of a motor vehicle and is injured. The ruling of the Pennsylvania court in Watson v. Lit Brothers (135 Atl. 631) is typical of the decisions in cases of this kind.

Pedestrian who suddenly steps in front of moving car is negligent. . . . Decedent, struck by truck, before attempting to cross street between intersections, was required to look for approaching traffic. . . . Truck driver was not bound to anticipate unexpected acts of persons not in path of travel suddenly placing themselves there.

Emergency vehicles, such as fire department trucks, police patrol wagons, and ambulances, are commonly given the right of way by ordinance over all private vehicles, including street cars, when proceeding to fires or emergencies or answering alarms and calls for service. A fire truck was held to have had right of way over a private truck at a street intersection although the "Stop" light was against the fire truck, in the case of Hartnett v. Standard Furniture Company (299 Pac. 408).

Emergency vehicles when engaged in answering emergency calls are allowed ordinarily by law to operate at speeds above the legal speeds for private vehicles. It is of first importance that a fire be reached in its incipiency. "To accomplish this purpose, the utmost haste is necessary," as stated by the court in the case of Kansas City v. McDonald (60 Kan. 481, 45 L.R.A. 429). According to another ruling:

The safety of property and the protection of life may, and often do, depend upon the celerity of movement, and require that the greatest practicable speed should be permitted to the vehicles of the fire department in going to fires. Farley v. New York, 152 N.Y. 222.

Many courts have held that drivers of emergency vehicles should maintain their vehicles under control and should be careful of the safety of other persons on the streets and highways even though the vehicles they are driving have the right of way, and that failure to do so is negligence. In Garrity v. Detroit Citizens Street Railway Company (37 L.R.A. 529), Mr. J. Grant says:

The rights and lives of people traveling on street cars and in other vehicles are as much entitled to protection as is property which is in danger of being destroyed by fire. In approaching this crowded thoroughfare (Woodward Avenue, Detroit) it was the clear duty of those having charge of the truck to have it under control.

In 1932, the Texas Court of Civil Appeals in Wichita Falls Traction Company v. Jeter, et al. (48 S.W., 2d series, 372), stated:

A mere exemption from the operation of speed laws cannot be legally construed as a license to operate a dangerous agency at cyclonic speed over public streets of a city, intersected by well-known streets and car lines and occupied by others. . . .

RELATION OF OBSERVANCE OF TRAFFIC RULES TO NEGLIGENCE

The rules of the road are not inflexible, and a strict observance should be avoided when there is a plain risk in adhering to them, and one who too rigidly adheres to such rules, when the injury might have been averted by variance therefrom, may be charged with fault. Ruling Case Law, Section 222.

Emergencies may arise where, in order to escape from danger to one's self or to prevent injury to others, it will not only be excusable but perfectly proper to temporarily violate the general rule. Elliott on Roads and Streets, 3d edition, Section 1080.

The observance of traffic rules does not in itself relieve a defendant of liability for collision nor, it would seem, prove a plaintiff free from contributory negligence (Erwin v. Traud, N.J. Ct. Er., 100 Atl. 184).

As stated in *Ruling Case Law*, Sec. 233, all travelers using a street or highway are required to observe ordinary care and caution to avoid inflicting injuries on other travelers with equal rights. It is their duty to look out for other vehicles passing, and to regard the ordinary rules of the road for each other's convenience and safety, and a violation of this duty constitutes negligence.

University Camps for Field Surveying

Specifications for University of Michigan Satisfied by Site near Jackson Hole, Wyoming

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IN 1874 the late Joseph Baker Davis, M. Am. Soc. C.E., of the University of Michigan, established a summer camp for the teaching of surveying to university students, probably the first in this country. That being in the days of horse-drawn vehicles, it was necessary for the site to be near the campus. When in 1904 Professor Davis made a long wagon trip with Professor Johnston through the Jackson Hole country, both were impressed with the facilities offered for a camp there and found inaccessibility the only drawback. After the development of good roads and motor transportation had removed this difficulty, considerable thought was given to deciding what the characteristics of an ideal summer surveying camp should be, regardless of its distance from the campus. This study resulted in the preparation of certain specifications, which Professor Johnston here records and explains. In 1928, with these as a guide, four members of the teaching staff went to Wyoming in search of a definite site. In 1929 Camp Davis was moved to a location in the Hoback Valley which complies with the specifications in detail. Operation of the camp for five seasons has proved that its distance of 1,700 miles from the campus is an asset rather than a handicap.

TO provide practice for students of surveying, summer camps have been established by many colleges of engineering. The first examples came into being during the early seventies. Their founders were the pioneers in a movement which demonstrated the value of camps where instruction may be given advantageously in several other subjects. Many universities now support camps at which courses are offered in surveying, forestry, biology, botany, geology, and geography.

Too frequently, particularly in the early days of the surveying camp, those in responsible charge were obliged to utilize waste lands where most of the prominent features of the ground surface were obstacles to field work in surveying. As a result, the young surveyor spent much of his time cutting brush and trees, crossing swamps and streams, and defending himself against the attacks of insects. He generally made contact with poison ivy, oak, or sumac merely to lend variety to his hardships. There were other handicaps in the field and at the camp that should not exist now that good roads and motor transportation have made almost any region of the United States accessible to all colleges and universities. But few colleges of engineering have thus far taken advantage of this era of mobility to select lands favorable to field work in surveying at any great distance from the campus.

Distance is no longer a serious handicap, and students are benefited by travel. For two decades teachers of engineering have been advocating courses and experience to broaden the horizons of students. A camp dedicated to surveying, located in conformity with complete specifications relating to the peculiar needs of the work to be done, the comfort and convenience of students, and the importance of scenic beauty, offers an experience equally profitable and inspiring.

A college of engineering in New England would find it feasible to occupy a summer camp for surveying work in Idaho, Washington, or Oregon. The colleges of the latter states could go to Maine or Vermont for the summer in so far as cost of travel is concerned. Because of the obstacles met with in regions where trees and brush flourish and for other reasons, camps of this kind should be established in the states west of the hundredth meridian and probably north of the southern boundary of Colorado.

Preliminary to a search for the camp site, the department interested should prepare written specifications setting forth, in the order of their importance, the natural and artificial features held to be essential or desirable. The specifications of the University of Michigan follow.

LAND SPECIFICATIONS FOR FIELD WORK IN SURVEYING

A minimum of two or three sections of land should lie adjacent to the camp site. The ground should have a gentle slope; the soil should be firm; and it should not support a growth of trees or brush. It should be possible to drive a truck anywhere in this area without great difficulty. The site should be partly surrounded by mountains and hills, but the hills should not be covered by brush or trees, since they are to provide opportunity for practice in topographic surveying. The mountains near the camp should add beauty to the landscape and offer a standing invitation to those interested in mountain climbing.

Summits of hills and mountains should be accessible without undue effort, as they are to be occupied as the local triangulation system expands. The base line would naturally be located on the open, smooth area adjacent to the camp. Public land surveys should have been completed in the neighborhood in order that students may become familiar with them and gain some experience in the retracement of old lines.

From the standpoint of field work in surveying, climate and topography should be considered together. Even though an area may satisfy the specifications already mentioned, it cannot be recommended unless there is ample assurance that the weather will be favorable for field work year after year. Although preferences regarding climate will vary with the tastes and prejudices of the individual, it is confidently believed that in the summer months many of the mountain valleys of the northwestern states are blessed with an atmosphere and general weather conditions that will satisfy all but the super-critical. A relatively dry country is to be preferred since rain is a handicap to field work. A large amount of precipitation also induces a growth of brush and trees and causes troublesome insects to increase. A locality subject to high winds during the summer months should be given a low rating. Sunshine, clear

FIELD SURVEYING CAMP OF THE UNIVERSITY OF MICHIGAN, IN HOBACK VALLEY, WYOMING. BASE LINE SHOWN IN WHITE

air, no oppressive temperatures, and cool nights are favorable conditions. Since observations are to be made on the sun and stars, a locality subject to fog and overcast skies should be avoided. The ideal elevation above sea level is from approximately 5,000 to 6,500 ft.

Climate controls insect life, but it would be difficult to find a good camp site where there are no insect pests. By careful planning, and possibly a little work, troublesome insects may be eliminated or reduced in numbers in most localities so that they will be scarcely noticed. When the search for a camp site is in progress inquiries should be made regarding local insect pests. Still water and marsh lands should be avoided. There are districts in the northwestern part of the United States where woodticks communicate the germ of spotted fever. These localities are well known and are of course unsuitable. Quite frequently the only troublesome insects in a locality are the mosquito and the buffalo gnat. These may be eliminated, or at least reduced in numbers, by improving the channels of small streams and by draining ponds and wet ground.

ESSENTIAL FACTORS IN THE SELECTION OF A CAMP SITE

An abundant supply of good water is the first essential. Proximity to mountains generally ensures a supply of excellent quality, which frequently can be brought to the camp under a gravity head. While the question of a water supply is being investigated, it might be well to consider the feasibility of a camp hydro-electric plant and of a garden to supply the mess with fresh vegetables. In most western states the right to use water from the streams is obtained by securing a permit from the state engineer. After a complete study of the possible uses of water at the camp, rights for domestic use, power, and irrigation may be obtained.

Where streams having considerable fall are not available, it may be necessary to resort to a well or wells. In such cases it is important to know the depth to water. A camp site should not be approved until the matter of water supply has been settled. A camp that is to be occupied each summer should have a water distribution system, and there should be running water installed in each residence building.

Where the water supply is good, a camp may be successfully established even if topography and soil are not entirely satisfactory. It is of course assumed that the lands adjacent to the site are suitable for field work in surveying. The less serious defects of local topography and soil may be alleviated or removed in any good program of development and maintenance, but there is no cure for a defective water supply.

When there is a choice of camp sites having a good water supply, that ground should be selected which has the best natural drainage. A knowledge of slopes is important in making the final decisions regarding plan and location. Water pipes that must be drained during the cold months of the year should be laid on a slope and provided with adequate outlets. The camp site should be as close as possible to the source of the water supply, assuming that a gravity system is feasible. In many mountain valleys the main supply pipe need not be more

CAMP DAVIS VIEWED FROM A POINT 300 FT ABOVE THE RIVER

than from 500 to 1,200 ft long to afford a satisfactory domestic pressure of from 27 to 35 lb per sq in.

A surface soil of shale clay or sandy loam having a slope of from 3 to 6 ft per 100 ft is satisfactory. Motor equipment may be driven almost anywhere on such ground when it is dry. The character of the surface soil and underlying material to a depth of from 12 to 20 ft may have an important bearing on the design and construction of the sanitary system. If the clay or sandy loam has a depth of 8 or 10 ft and the underlying material is porous, such as coarse gravel and water-worn rock, it may prove economical to install several steel septic tanks rather than to construct a long sewer leading to a single septic tank. The effluent from the steel septic tanks may be carried to the underlying porous material, if such exists, at a reasonable depth below the ground surface.

A modern surveying camp must depend on motor transportation. It would be handicapped if located too far from a public highway. The construction and maintenance of a road to connect the camp with the main highway is an item to be considered in choosing the site.

Light motor trucks should be furnished by the college for the service of the camp. The college also might maintain enough passenger cars for the transportation of the staff, but students should provide cars for their own transportation. It has been proved that this is not an important item of expense. Students can economize in many ways, and they gain valuable experience as they make their own plans for transportation. Although motor equipment may be a handicap to them at the university, it is an asset at the surveying camp. Young people are naturally interested in travel. Many of them drive motor cars considerable distances each summer without any special objective. A summer camp provides them with a goal. If it is located near National Parks or in any region of natural beauty, they will find inspiration and recreation in week-end travel and exploration.

PERMANENT CAMP BUILDINGS

A camp for field work in surveying should be considered as a permanent item in the property assets of the college. Although the actual surveying work generally demands a frequent change of base, the teaching improves as the same lands are used for a long term of years, providing of course that these lands were selected with care in the beginning. This is because teaching improves as field data accumulate. The professional field party often depends on tents for shelter, but these are not suitable for a permanent camp. The care of canvas for housing a group of from 40 to 80 persons entails burdens known only to those who have done it. Other and better materials are now available. Camp buildings should be so designed and constructed that they will serve for many years without high maintenance cost. Buildings should provide storage space for other camp equipment instead of themselves constituting an addition to the weight and bulk of materials to be stored while the camp is not occupied. Galvanized sheet steel attached to a timber framework provides a cheap, comfortable,

and durable building. A coat of aluminum paint once in 10 or 15 years will preserve the steel almost indefinitely. Concrete floors and brick chimneys are recommended. Such a building costs little more than a tent of the same area, with fly and board floor. Within a period of four or five years the permanent building shows economies that would justify a considerably larger outlay on initial construction.

JACKSON LAKE AND THE TETON MOUNTAINS
From a Point Fifty Miles North of Camp Davis

In any comprehensive search for a site, some attention should be given to the availability of building materials. A camp situated not far from a sawmill, a coal mine, and a gravel pit has advantages that should not be overlooked. Since sheet steel, brick, hardware, and other building necessities may have to be shipped in by rail, it is important that the camp be not too far from a railroad. The character of the roads connecting the site with the nearest railroad is helpful in making preliminary estimates. It may be well to select a site somewhat remote from a railway if the annual maintenance costs are not thereby increased and if there are compensating gains in other directions. In other words, it may be advisable to pay a slightly higher rate for building material and its transportation if this extra outlay is to be returned by reduced costs for lumber, gravel, fuel, and supplies for the mess and possibly for the camp store.

The camp plan is influenced by topography, character of soil, proximity of lakes and rivers, direction and location of permanent roads, drainage, source of water supply, and many other elements. Since the camp is to foster field work in surveying, it should be so planned that students can procure instruments and all necessary equipment with a minimum of delay and begin field work within its limits when desirable. An open space near the camp with a clear view to the north is favorable for astronomical work. If there is a mathematical center or other important point in this open space, a monument may be placed there to mark a station on the camp meridian. The same monument may be used as a coordinate center to which all local surveys may ultimately be connected. It would also serve as a convenient bench mark and would bear the elevation above sea level. In this connection it may be said that astronomical work will be facilitated by locating the camp along the southern margin of the smooth, open area previously mentioned. The camp meridian would then traverse the open area and could be extended several miles, or even to the north horizon.

A residence building 14 ft square affords ample space for four students. Steel double beds, double-decked, are economical of space. Each building should be provided with a clothes closet and clothes hangers, electric lights, a stove, a lavatory, a table, four chairs or two short benches, shelves for books, and racks for towels. Gasoline lamps are good where electric current is not available but are not as safe or convenient for general use. Each member of the staff should have a building to himself because he must be accessible to the group of students who are working under his supervision at the time. Two or three buildings should be reserved for the accommodation of visitors; one should be set aside for the camp store; and two or three for offices.

Where a lake or river is not available for swimming and bathing, buildings wherein hot and cold showers may be installed can be provided at low cost. Small water heaters cost about $25, and shower fixtures, $7 or $8. The necessary plumbing and extra concrete work should not exceed $20. Such a shower would accommodate from 15 to 25 people. Standard toilets may be placed in the same building, thus combining the usual bathroom fixtures. For a camp of 40 students, three such buildings are ample—two for the use of the students and one for members of the staff and visitors.

The general buildings of the camp would consist of a kitchen connected with a dining room, a residence for a keeper, an instrument room, a shop, and a building for the storage of miscellaneous equipment and materials. An inexpensive gasoline engine and a small generator may be installed in the shop. Also, a modern surveying camp should have a dark room where films can be developed and prints made. A building to shelter motor equipment would be helpful but is not essential. A clubhouse with a fireplace is a definite asset. It could house a small library made up of books for the students to read when off duty. The clubhouse would provide surplus office space and a gathering place for special lectures and motion pictures.

MISCELLANEOUS FEATURES

A tract of land lying adjacent to a Federal Forest Reserve should be considered advantageous. The Forest Service does not object to a reasonable use of reserve lands providing damage is not done to trees or other resources. An area of 40 acres, or even less, would provide ample area for the camp. In many places the purchase of a small amount of land affords all the protection generally to be desired. The Forest Service extends a kindly hand to those who represent higher education, and its local officers are friends and good neighbors.

Wood or coal or both may be used for fuel. Both are often available at reasonable prices throughout the northwestern states. Dead wood to the amount of eight cords per family per year may be removed from forest reserve lands without charge. Coal of good quality can be delivered to many camp sites for from $6.50 to $9 per ton.

Postal service has been extended to all parts of the country. Telephone connections can generally be provided at little cost. A camp located two or three thousand miles from the university that sponsors and supports it can keep in touch with the parent institution by short-wave radio communication.

Good roads and the automobile bring hospitals and physicians within call over a wide area. If there is a practicing physician within 40 or 50 miles of the camp and he is connected with the camp by a good road, he can be brought to the camp, or a patient delivered to his care, in an hour or a few minutes more. Telephone service is invaluable in emergency cases. If there is a

hospital within a hundred miles it will probably serve the camp in a satisfactory way. It is not necessary for the camp to retain a physician, but some member of the staff should understand first-aid treatment and should have at hand such supplies as a hospital or health service would recommend.

A mountainous country appeals to all who are interested in exploration, students not excepted. The mountain climber always wonders what is hidden behind the next mountain; his curiosity is not satisfied until he has scaled the highest peak in the range. The mountains of the northwestern states contain glaciers, eternal snows, beautiful lakes and rivers, a wide range of geological formations, interesting wild animal life, and a flora that intrigues the newcomer. The wild flowers of the mountains would in themselves justify a journey of several thousand miles. Isolation has its advantages for any camp that is to foster learning.

A locality infested with venemous snakes would not appeal to those in search of a permanent site for any camp. There are places in the northwestern states where rattlesnakes are common, but these snakes are seldom found on ground that would be considered suitable for a camp. Regions subject to forest or prairie fires are seldom attractive. Such fires not only threaten the destruction of property but often result in a suspension of regular work when a force is drafted to combat the flames. Smoke is a serious handicap to such field work as triangulation and astronomical observations.

CAMP MESS IMPORTANT

Because food must be provided regardless of the conditions under which people live, the importance of the camp mess may frequently be underestimated. Private profit should be eliminated. A member of the teaching staff should administer the mess. A little experience in this kind of work affords data for estimating costs. Each resident of the camp should deposit a fixed sum with the mess department at the beginning of the session. Sixty dollars should be sufficient to cover all expenses for a period of eight weeks, allowing for a 3 to 5 per cent breakage fund and a cash rebate of from $10 to $15 at the end of the season. The mess should have enough money at the beginning of the session for the purchase of staple supplies in wholesale quantities. It is preferable to require a deposit approximating an excess of 30 per cent of the amount each resident of the camp is finally to contribute toward the support of the mess. The rebate represents cash that the mass has saved for students and others. It is always appreciated as it often covers the expense of the return journey. A complete accounting should be made of all moneys received and spent. The supplies purchased for the mess should be analyzed each year and a tabulation preserved for the guidance of the mess department in the future.

When the search for lands and a camp site are in progress, inquiries should be made regarding the availability of fresh milk, meats, vegetables, and fruits. Lands that might be favorable in most respects may be so far removed from farms and wholesale dealers as to make them unsuitable. The camp mess is a local barograph, which records satisfaction or discontent; success or failure.

UNIVERSITY OF MICHIGAN'S SELECTION

For 55 years the University of Michigan maintained a surveying camp about 300 miles from the campus. The estimated cost of the work for students during that period approximated $125 per year. A few years ago the camp was moved to a site in the Rocky Mountains, 1,700 miles from the university. Student costs have not materially increased. Individual students have attended the new camp at a cost of from $103 to $110, and groups have not exceeded an average of $125. The average cost for the entire student group for one summer was very close to $150. Nearly a third of the students of this group spent considerable money for photographic material, motion pictures, dances, and other social activities. Five or six students made extensive tours late in August, after the work at the camp was concluded.

OLD BRIDGE IN HOBACK CANYON
Four and a Half Miles East of Camp Davis

Some of the accompanying photographs show the lands selected for a surveying camp by the University of Michigan in conformity with the preceding specifications. Others portray features of the neighboring scenery. The camp is located in the valley of the Hoback River, Wyoming, a tributary of the Snake River, about 75 miles south of the southern boundary of the Yellowstone National Park and immediately south of Jackson Hole. It is probable that John Coulter descended the Hoback River in 1807 with a friendly band of Indians. A few weeks later he explored the area now embraced within the boundaries of the Yellowstone National Park. In 1811, the Astorians under Hunt followed the same stream after leaving their temporary camp on Green River. Their guide, John Hoback, remained in northwestern Wyoming and eastern Idaho as a trapper and hunter.

Summarizing the main facts borne out by experience with Camp Davis, it may be said that lands for university surveying camps may now be chosen wherever favorable conditions are found within the limits of the United States. It is unnecessary to impose hardships on students and teachers. Teachers of surveying established the first university camps; they should be excellent judges of topography, climate, and all conditions that are favorable to the work they represent. In the first place, it is important that the lands chosen be suitable for field work. A camp has a chance to develop and improve where the basic features of the specifications are observed at the time the site is chosen.

Camp Davis was established in 1874. Many similar camps have come into being since that time. Camp Davis retained its pioneer tendencies when it was transferred to a country where all conditions were favorable for the work it had fostered for sixty years. It is to be hoped that other colleges and universities will soon establish surveying camps in the mountain valleys of the great Northwest.

The Tepuxtepec Rock-Fill Dam

A Major Flood-Control and Irrigation Project in Southern Mexico

By H. E. M. Stevenson

Junior American Society of Civil Engineers
Resident Engineer, Texas State Highway Department, Lampasas, Tex.

EARLY in May of 1926 the Mexican Government, under the Calles administration, began the greatly needed flood-prevention and irrigation development in the valley of the Rio Lerma, 120 miles southwest of Mexico City. In this article Mr. Stevenson, who was the construction engineer on the work, gives a general description of the important features of the Tepuxtepec Project. A badly fractured foundation necessitated deep excavation for the cut-off, cement grouting at pressures up to 100 atmospheres, and the design and construction of a steep-sloped rock-fill dam, made possible only by the cheap labor available. This article has been prepared from the paper read by Mr. Stevenson before the spring meeting of the Texas Section of the Society on May 11, 1934.

TEPETONGO, the rail head for the Tepuxtepec development, is on a narrow-gage road of the National Lines of Mexico, in the State of Michoacan, some 112 miles northwest of the City of Mexico. The development is at an elevation of 8,000 ft, eight miles northwest of Tepetongo, on the Lerma River. This very flashy river lies in the Pacific drainage area and receives its supply from rainfall and from the melting snows of Mount Toluca. Its source is in the central part of the State of Mexico, in Lake Lerma, near Toluca. It flows northwest into Lake Chapala in the State of Jalisco. The waters from this lake flow northwest down the Santiago River, emptying into the Pacific Ocean near the City of Santiago, State of Nayarit. In its turbulent course the Lerma River has brought disastrous floods to the Acambaro district, one of the most thickly populated and finest agricultural regions of the Republic of Mexico.

PLAN FOR IRRIGATION AND FLOOD CONTROL

It was the plan of the National Commission of Irrigation to construct a flood-control dam and storage reservoir using the impounded waters to irrigate the fertile agricultural lands in the lower Lerma Valley. The dam as originally envisaged by the Commission was a concrete gravity-section type approximately 150 ft high. After extensive studies of various dam sites by government engineers, a contract was entered into by the Mexican Government and the German firm of Siemens-Mexico, S.A., for the construction of the dam near the small village of Tepuxtepec.

At this stage, the Compania de Fuerza del Suroeste de Mexico, S.A., a subsidiary of the Mexican Light and Power Company, Limited, applied to the government for a concession to use, for power development, the waters made available by the construction of the dam. Further negotiations resulted in a formal contract between the company and the government whereby the former took over from the firm of Siemens-Mexico the construction of the dam. According to this arrangement the dam was to be built at the company's expense, whereas the irrigation canals and laterals were to be financed and constructed by the government. The ownership of the storage works and the water was to be retained by the government, with the right to stipulate the fixed service plan under which the company was to develop hydro-electric energy.

As a result of further investigations, the design of the dam was altered to a steep-sloped rock fill. The storage basin was planned for a capacity of 405,000 acre-ft, and the quantity of water available for irrigation and water power was set at 600 cu ft per sec. According to this plan, the work was continued through 1927 and 1928, and the dam was completed late in 1929.

Downstream Face of Dam, Looking South Toward Crushing and Mixing Plant

GEOLOGIC FORMATION PRECLUDES GRAVITY DAM

Results of the exploration of the Tepuxtepec site showed clearly that the concrete gravity structure originally planned was not feasible. Further, the site was in the area of what is geologically known as the Acambay Fault zone. This is a strong northeast fault line passing some thirty miles northwest of the site. The last active movement along it was in 1914, when strong shocks shook down adobe buildings and a stone chapel on the Hacienda de Dolores 20 miles northwest of the dam site.

Thus the design of the dam was changed to a steep-sloped rock-fill dam with a flexible upstream paving of dense high-strength reinforced concrete. The theory of the design was that, should a geological displacement take place due to earth shocks, the steep slopes would tend to be shaken flatter, and the flexible mat of concrete would follow the rock fill down and thus tend toward a partial failure rather than a great disaster.

Accordingly the section was given a base width of 240 ft, a crest width of 15 ft, and a maximum height of 123 ft. As shown in Fig. 1, the upstream face has a constant slope of 0.7:1, whereas the downstream face gradually steepens from a 1:1 to a 0.7:1 slope. The weight of the rock, which is an extremely tough basalt, was taken as being 133 lb per cu ft. Specifications called for an average fill density of 80 per cent. Actual tests on model specimens of the fill, made by hydraulic displacement of mass, showed an average of 25 per cent voids in the hand-chinked masonry fill.

Two layers of reinforced concrete, bearing against concrete blocks poured directly against the rock fill, form the upstream paving. These two slabs are separated by a 1-in. thickness of special asphalt and are tied into the concrete backing by vertical keyways spaced 25 ft apart. The method of breaking the joints and of alternately keying the upper and lower slabs will be better understood by reference to the detail in Fig. 1. The downstream face is of dressed stone set in 1:3 mortar. Drains connecting with the main foundation drains were left at various elevations in the masonry to provide for any filtration. The dam has a crest length of about 900 ft and contains approximately 91,000 cu yd of rock and 17,000 cu yd of concrete.

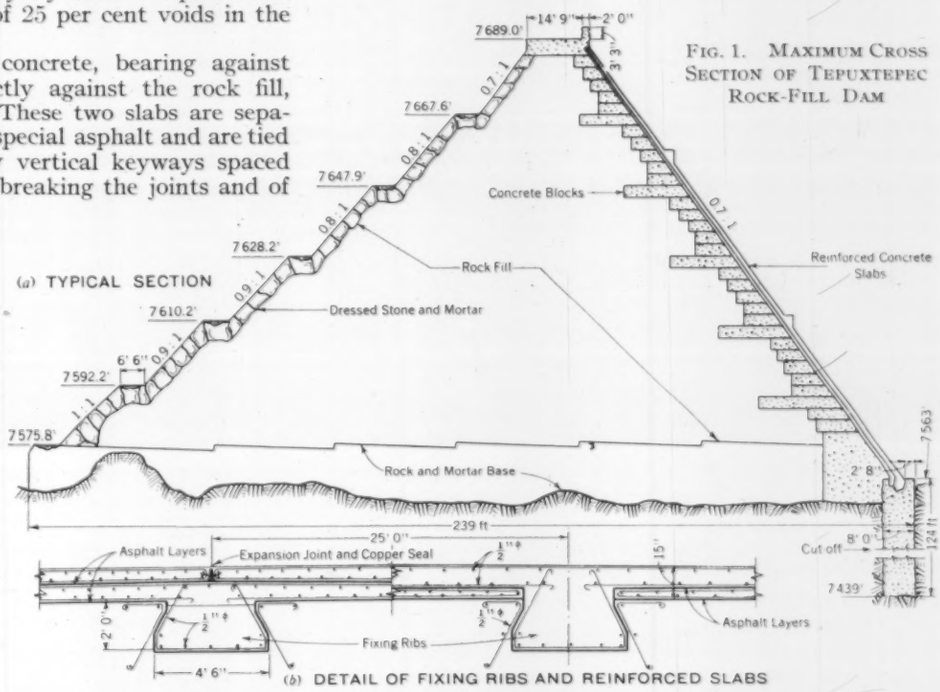


FIG. 1. MAXIMUM CROSS SECTION OF TEPUXTEPEC ROCK-FILL DAM

EXPLORATION OF THE SITE BY VARIOUS METHODS

In addition to the work done by the government, extensive diamond drilling, test pitting, and tunnel driving were done by the Compania de Fuerza del Suroeste under the direction of W. H. Grant, consulting geologist of San Francisco, Calif.

The geology of the site is very complex. Underlying a thick mantle of "tepetate" or tuff, the basaltic formations were found to range from a dense massive to a vesicular, from fresh to altered, with pockets of scoriated material that could be removed without the aid of explosives. In some zones, a formation known as *aa* lava, common only to this locality and to the Hawaiian Islands, was uncovered. This interesting formation is composed of basalt spalls, ranging in diameter up to 6 in., all firmly cemented together. Its physical appearance would suggest that it had been fired from some giant cannon. Data obtained from this exploration indicated the presence of a major fracture in the stream bed, requiring a deep cut-off wall.

Unwatering of the site was accomplished by diverting the river through a horseshoe-shaped tunnel 900 ft long, 18 ft in diameter at the springing line, and lined with 12 in. of concrete. Its capacity is 2,100 cu ft per sec. As it was to be used as a permanent irrigation outlet, it was equipped with a cylindrical concrete plug-gate operating in a concrete tower set over the intake opening. This plug-gate, or valve, was manufactured in Italy.

At the tunnel intake a diversion dam was built consisting of concrete buttresses 6 ft thick, spaced to give clear openings of 10 ft, which were closed by wooden stop-logs. The buttresses had a crest width of 10 ft and an average base width of 27 ft. The length of the dam was 330 ft, and its crest was 25 ft above the lowest bedrock. These works functioned normally during the flood seasons; at no time was the construction at the dam site in danger from high water.

DEEP CUT-OFF REQUIRED

An important feature of the excavation was the deep cut-off in the central part of the stream bed, as shown in Fig. 2. This was made necessary by the presence of the fracture found during the exploration work. This fracture was filled with clay, scoriated material, breccia, and badly fractured, platy basalt. A depth of 125 ft below the stream bed was reached before a reliable foundation was encountered. The cut-off wall has an average thickness of 8 ft and is of dense concrete.

On account of the poor foundation material, special efforts were made to obtain impermeability. Grouting at an extremely high pressure, a maximum of 1,500 lb per sq in., was accomplished with equipment imported from Stockholm, Sweden. This equipment consisted of an electrically driven hydraulic pump, a double-chambered mixing drum, and special high-pressure gages and fittings.

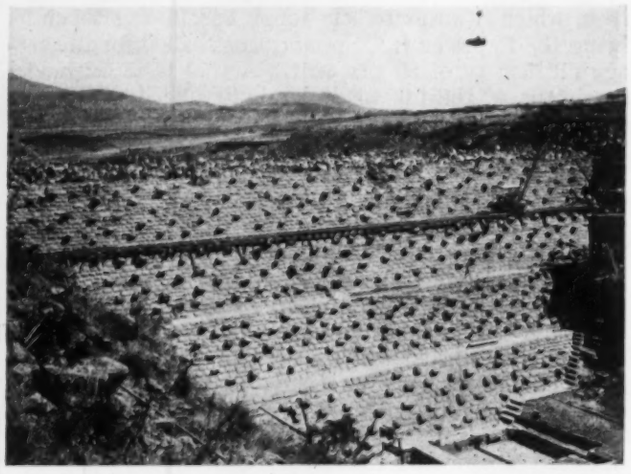
Grout holes were drilled along the cut-off on an average spacing of 15 ft, to depths corresponding to the reservoir head at that point. First the holes were washed with clean water; then neat cement grout was pumped into them to refusal, the pressure being raised in direct proportion to the resistance offered by the underlying formations. When the maximum pressure was reached, it was applied to the hole for one hour to ensure tightness. In some instances a temporary plugging would occur, only to be broken down by the constant pressure.

There was no uniformity in the pressures required. Some holes took only one sack of cement at a pressure of 50 lb; others took 20 tons at a maximum pressure of 1,500 lb. Some holes required days to fill. A continuous shift of workmen was therefore necessary. These men became expert in handling the equipment. Test drill holes showed that satisfactory results were obtained in this important high-pressure grouting.

The spillway is of the open-channel type, approximately 900 ft in length and lined with concrete. Its rated capacity of discharge is 35,000 cu ft per sec.

North, east, and southeast of Tepuxtepec extends the Yerje Valley. Five other valleys, like the fingers of a giant hand, converge in it to form the Tepuxtepec Reservoir, which at ultimate crest elevation will impound 405,000 acre-ft of water. This reservoir extends for a distance of 10 miles above the dam and creates a shallow but picturesque lake, with one finger reaching into the State of Guanajuato.

Looking Toward South Abutment After Unwatering of Site



Downstream Face of Structure Nearing Completion

TEPUXTEPEC ROCK-FILL DAM IN STATE OF MICHOACAN, MEXICO

CONSTRUCTION METHODS USED

Driving of the diversion tunnel was done by the heading and bench method, using two headings. Drifters, mounted on horizontal bars, were used for advancing the headings, while jackhammers were employed on the benches and for trimming to the neat line. Muck was shoveled by hand off steel muck plates into $^1/_4$-yd side-dump cars which, in the intake heading, were hand-trammed to the portal shaft, up which the muck was hoisted to the surface. In the outlet heading, an inclined adit was used, and the muck was hauled directly to the surface by a 5-ton air hoist. The lining was hand-placed against wooden forms, the concrete being mixed at the outlet portal in a 1-cu yd mixer.

All the firing was done by fuse, using 60 per cent nitroglycerin in the headings and 40 per cent on the trim and benches. These explosives were of local manufacture and gave excellent results. The headings were cleared of powder fumes after each firing round by blowers.

The deep excavation for the cut-off foundation presented a problem since the cableway, purchased in Scotland, did not arrive in time to be used for this work. Instead, three mine-type head-frames, each handling 1-cu yd buckets, were erected over the trench and the muck hoisted to the surface through shafts. Hand-trammed $^1/_4$-cu yd side-dump cars hauled the muck from these frames to a spoil bank on each side of the river below the outlet of the diversion tunnel.

Excavation for the spillway channel was accomplished by a $1^1/_2$-cu yd shovel operated by compressed air. The concrete lining was placed in wooden forms, which were filled from a track running from the mixer plant down each side of the spillway.

For transporting the rock and concrete to the dam, a 10-ton cableway, with a 120-ft fixed head-tower and a 70-ft radial traveling tail-tower, was used. Rock from three quarries, loaded in $2^1/_2$-yd skips, was brought under the head-tower in trains of from 6 to 10 cars. Three trains were used, each hauled by a 20-ton saddle-tank, oil-burning locomotive. The skips were then transported by the cableway to the working areas. In the main, the masonry fill was hand-placed after being dumped from the cableway skips. The rock was spread in horizontal lifts, and at no time was piling permitted. Native laborers, at an average wage of 60 cents (United States money) per day, were employed for this work.

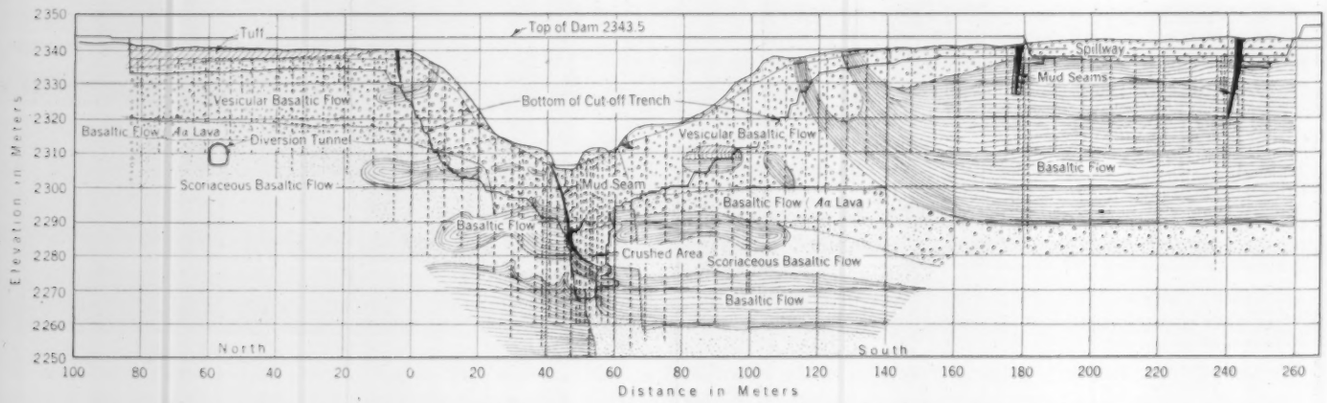
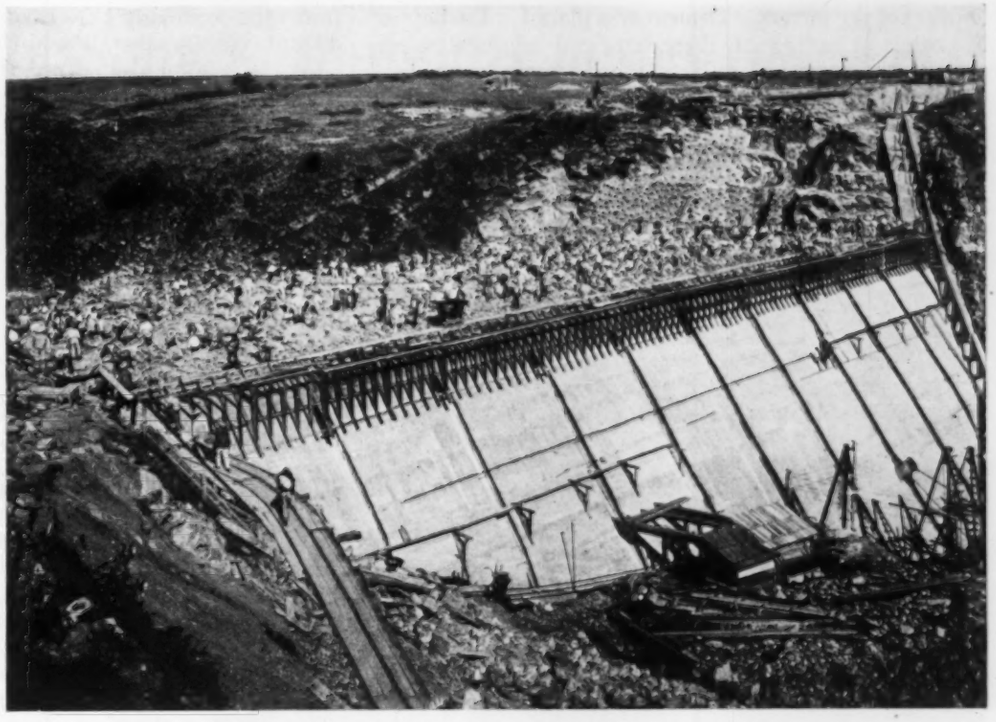


FIG. 2. GEOLOGIC CROSS SECTION THROUGH CUT-OFF TRENCH OF DAM, LOOKING UPSTREAM
Showing Grout Holes, in Which 254 Tons of Cement Was Placed Under Pressures Up to 1,500 Lb per Sq In.

For the upstream blocks, the concrete was placed by cableway by means of 2-cu yd bottom-dump buckets, directly against the rock fill. Wooden forms, with tie wires and pipe braces, were used in lifts of 3 ft. Rock and concrete were carried to the same elevation across the entire length of the dam before a new lift was started. The downstream face of trimmed rock was placed by a 2-ton gasoline crane with a 125-ft boom. Projecting rocks were left in this face to provide bond for the additional width, when the dam is raised to full height. Concrete in the flexible upstream mat was also placed by the cableway through hoppers on the crest discharging into tremie pipes extending down the face of the dam and into the wooden truss forms of the slabs.



UPSTREAM FACE OF DAM, SHOWING CONCRETE BLOCKS AND KEYWAYS, AND WORKMEN PLACING ROCK BY HAND

The 1-in. thickness of asphalt was made up of two $\frac{1}{2}$-in. precast sheets of an asphalt made especially for this dam. The manufacturer's chemists assisted greatly in obtaining the correct blend of asphalt—one that would not creep under the hot tropical sun during periods of low reservoir level nor crack and become brittle during the cold tropical nights. These sheets were cast in a specially built "pouring room," were about 3 ft square, and were reinforced with expanded metal. They were placed on the upstream face of the dam, stuck in place with hot asphalt, and the joints between them sealed with electrically heated spatulas of special design. Joints between upper and lower layers of asphalt were staggered as much as possible.

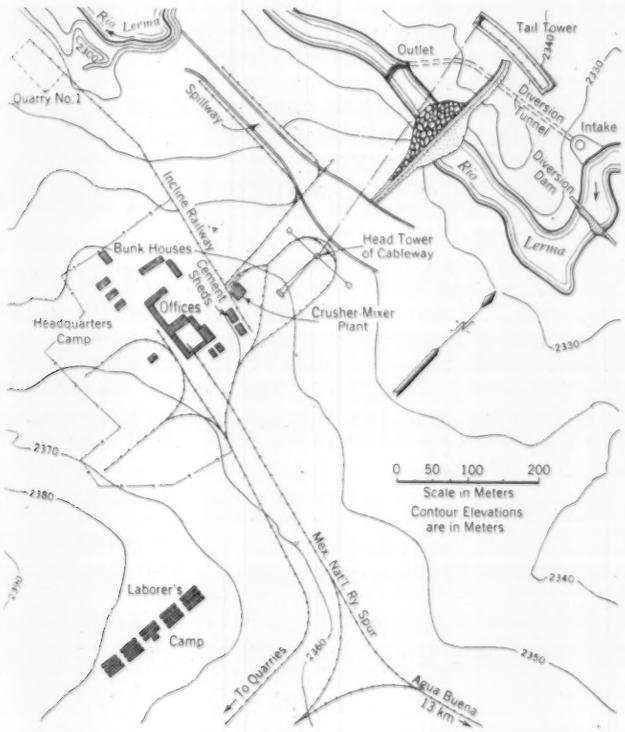


FIG. 3. LAYOUT OF DAM AND CONSTRUCTION PLANT, TEPUXTEPEC PROJECT

In constructing the dam, the greatest problem was the production of rock. Because of the many different formations uncovered, difficulty was experienced in keeping a working face. Waste ran as high as 50 per cent, and in some instances an entire shot would be fired in material unsuitable for the dam. The open-face method of excavation was used. Black powder was loaded in vertical holes drilled by deep-hole rigs. An air-operated railroad shovel, a 2-ton electric car-derrick, and many small portable 2-ton stiff-leg derricks driven by air were used to load the rock into skips, which were set on individual flat cars.

A crusher-mixer plant, erected at the south end of the dam, furnished laboratory-designed concrete to the cableway. Concrete, mixed by a battery of 1-cu yd mixers, electrically driven, was transported to the head tower of the cableway by a 5-ton gasoline locomotive pulling two 2-cu yd bottom-dump concrete buckets. The crushing cycle was as follows. Quarried basalt, raised to the plant over an inclined railway in 2-cu yd side-dump cars, was dumped on to an apron feeding a gyratory crusher. A bucket elevator raised the product from the crusher to a revolving screen, which discharged into bins of 125-cu yd capacity each. Oversized rock was carried off the end of the screen into a rejection chute, which fed two sand mills and two jaw crushers. These dumped on a 24-in. conveyor belt, which fed back to the bucket elevator.

Batchers and inundators hung directly beneath the bins and measured the aggregates, which were dumped into an end-dumping car pushed by hand to the charging

hoppers of the mixers. Cement was placed in the hopper by hand. Grading of these artificial aggregates, especially the fines, had to be watched closely to ensure a uniform concrete. Trouble was experienced at first in keeping a uniform sand, due to excessive wear of the hammers in the sand mills. This was corrected by stationing an operator at each mill to raise the breaker-plate to meet the wear of the hammers.

Cement from a plant in Mexico was shipped by rail to the dam site, where it was stored in warehouses.

TEPUXTEPEC DAM NEARING COMPLETION—SPILLWAY CHANNEL IN FOREGROUND
Ten-Ton Cableway in Operation

These were connected to the hoppers at the mixers by an inclined railway operated by an air hoist.

A complete testing laboratory was maintained for rigid control of the cut-off and paving concrete. The equipment included a 200,000-lb compression machine, a tension machine for briquettes, and apparatus for the chemical testing of cement. Permeability tests of the concrete and all physical tests of the asphalt used in the upstream paving were also made there. Tests were conducted on all concrete at 28 and 90 days to check design strengths.

Because of the harshness of the aggregates, some difficulty was experienced in designing workable mixes that would remain within the limits of the specified strengths. This was overcome by a close check of the mechanical grading of the aggregates, as produced at the crushers and mills. The water-cement ratio was used for all concrete. The field mixes were, by volume:

USE	MIX	CEMENT, BBL PER CU YD
Cut-off	1:2.75:3.5	1.2
Paving	1:2.3 :3:2	1.5
Concrete blocks	1:4.7 :4.7	0.9
Spillway lining	1:4.2 :4.2	1.0

These proportions resulted in plastic, workable mixes, all giving the required high strengths at 28 days.

Two deep-hole drills put down the grout holes in the cut-off trench. These rigs had a capacity of 100 lin ft of hole. For the deeper work, two diamond drills were used, both operated by experienced American drillers.

On account of the remote location of the project, well-equipped shops were maintained at the site, including machine, blacksmith, and carpenter shops and a foundry, a saw mill, an electric-arc welding booth, and a complete rigging loft. Major repairs were handled and many spare parts made in these shops. Electrical energy was delivered to the site over an 80,000-v transmission line from the company's Necaxa Plant, some 200 miles distant, via the substation at the El Oro Mines.

At the headquarters camp, which was at the dam site, were located the administration offices, stores, commissary department, staff, and general mess halls and bunk houses accommodating 32 men. Houses for eight families were built and occupied by members of the construction staff. A field hospital, with a fully equipped operating room and a 12-man ward, was maintained throughout the construction period. Drinking water obtained from springs was filtered and chlorinated for camp use.

A compound of "tejaminal," or shingled shacks, was provided for 1,000 workmen and was occupied by the peon class of labor. The skilled workmen lived in the town to Tepuxtepec. A barracks housing a detachment of 50 Mexican federal soldiers was built on a hill overlooking the headquarters camp.

Fortunately the project was situated in the heart of a rapidly declining mining district, where experienced native labor of all classes was abundant. A maximum of 3,600 men was employed, and the average was 1,500 men. Two political revolutions took place during the period of construction, the Serrano-Gomez and the Escobar uprisings. Both were short-lived and had but a brief influence on the work.

A total estimated settlement of 1.6 ft from the constructed crest elevation of 7,689.0 was allowed for in the design. A close check was kept on the settlement of the structure during construction. In the downstream berms and the two steps of the upstream paving, brass bolts were set both for alignment and grade. On each side of the gorge there was a transit station—a concrete monument set in the rock wall of the abutment, corresponding to the elevation of the berm on that side. Any movement up or down stream was observed by setting a transit over the monument, foresighting across the gorge to a corresponding monument, and then observing the position of the punch mark on the bolts on the berms. Settlement was measured by direct leveling from benches set on the transit stations at each end of the berms. Observations up to the time of my departure disclosed a maximum settlement of 0.018 ft and no deflection up or down stream.

All construction was executed in conformity with the policies, and under the direction, of the National Commission of Irrigation appointed by the President of Mexico. The original commission appointed by President Calles was composed of F. A. Salido, J. S. Mejorada, and J. Mares. During the provisional term of President Portes Gil, the commision was composed of R. Gayol, M. Am. Soc. C.E., A. G. Gallardo, and G. Robles, with I. L. Bancalari as director general.

The consulting engineer was A. Omodeo, whose offices are in Milan, Italy. He was represented at Tepuxtepec by G. Tonini and G. Gibellini, the latter being the company's hydraulic engineer, with offices in Mexico City. The late Willis Ranney, M. Am. Soc. C.E., was construction superintendent; J. B. Giono was assistant superintendent; and I was construction engineer.

For the Mexican Light and Power Company, Limited, G. R. G. Conway, M. Am. Soc. C.E., is president and resident director. He has offices in Mexico City and in Toronto, Canada. W. H. Fraser, the general manager, has offices in Mexico City.

Etymology of Some Common Engineering Terms

Present Usage Traced from Study of Historic and Linguistic Background

By Richard S. Kirby

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Chairman, Department of Engineering Drawing, Yale University, New Haven, Conn.

ETYMOLOGY is an old science—at least it is known that the Greeks before Plato made some inquiries into the subject. Also, the derivation of the word is Greek, from two words signifying "true account." However, to give a "true account" of the history and origin of a word is often difficult for many reasons. Especially is this the case with engineering terms, which appear rather rarely in the older literatures and are therefore hard to trace. Because of the recent advancements in the engineering art many such terms, in their present meanings at least, date back only to the last century. But these also may present problems and may only appear in written form after they have become established by usage. In this article Professor Kirby has assembled a group of words of special interest to engineers and has presented the results of his study of their history and origin.

NO one can know too much of the history of the race. History deals with persons, governments, institutions, arts and sciences, even languages. If anyone knew all about the antecedents of his own everyday vocabulary he would have made a fair beginning at history. The following sixty or seventy words—words somewhat peculiar to the engineering profession—have been used for years by English-speaking engineers, probably without much thought of their origin. This informal attempt to follow their meaning back through the centuries to more or less tangible "origins" may therefore be of interest.

BRIDGES

A BASCULE bridge is, etymologically, simply a bridge whose hinder parts sit down (from the Latin, *bas*, down and *cul*, posterior). The immediate derivation is probably from the French, now *bascule* and formerly *bacule*, a see-saw.

The word BRIDGE is Germanic, Scandinavian. In 1556 it was related that "Thys yere sank a parte of London brygge with two arches." When, a century later, Pepys spoke of a bridge, he sometimes meant simply a landing place. Used in this sense it may be found on old maps of London.

CAMBER comes from the French through the Latin. The French *cambrer* means to arch slightly and is a semi-popular derivative of the Latin *camerare*, to vault. Terms closely related are *camera* and *chamber*.

CULVERT is of obscure origin, but probably dates back only to the beginnings of English canals, or about 1770. It seems to have crept into the language through a local dialect, and it may have been a corruption of the French *couloir*, a channel or gutter. One authority strongly hints a French-Dutch origin, from *coul*, suggesting flowing, and *vaart*, a canal. A distinguished English philologist hazards a wild guess that *culvert* may have been an engineer's surname, as *macadam* was.

GIRDER is from the Anglo-Saxon, meaning of course something that supports or holds up. In its present sense its use is of course very recent.

In the days of coats of armor, GUSSETS were triangular pieces of chain mail introduced to fill up a space at the joints between two adjacent pieces of mail, as for instance under the armpits, to give flexibility. The term is still a familiar one to dressmakers.

JOIST comes through the French, probably from *gîte*, a resting place, which can be traced back through the old French *gésir* to the Latin *iacere*, to lie. By analogy, beams lower down are thought of not only as resting but sleeping and are called *sleepers*. The carpentry specifications for Queen's College, Cambridge, in 1448, required that "The Gistes shall be on the one part square vi inches and on the other part viii inches."

PANEL in Middle English meant a little piece of cloth; then almost anything of similar shape, as a pane. A jury panel was a list written on a piece of parchment.

RIVET is perhaps Scandinavian, through Highland Scotch. Other authorities connect it with the French verb *river*, meaning to fix or clinch.

STRUT, of Scandinavian descent, came into English through the Old English *strut*, to stand out, project, protrude, implying rigidity. Its immediate origin is obscure.

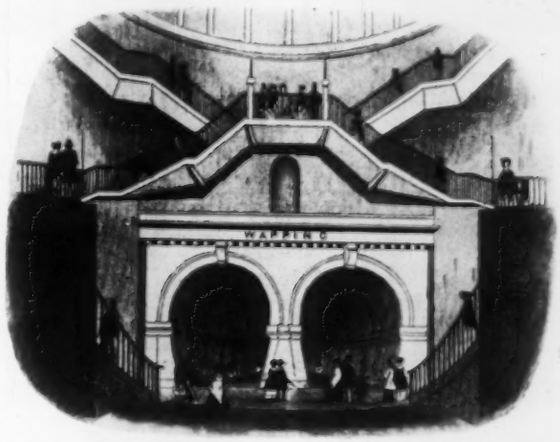
TRUSS is from the Old French, *trousser*, to truss; hence to make a bundle or pack. The term is still used in the diminutive, *trousseau*, a little bundle.

WELD is from an alteration of the past participle of *well*, a word of Scandinavian origin used in the sense of welling up or softening from intense heat. In one edition of Wyclif's (fourteenth century) translation of Isaiah ii, 4, we read, "Thei shulen welle togidere her swerdes in-to scharris" (They shall weld together their swords into plowshares), a consummation still devoutly to be wished for.

MASONRY

ARCH is from a late Latin word *arca*, meaning an ark or chest, or perhaps it is from the earlier *arcus*, a bow.

ASHLAR, which comes from the French, meant first a plank, then a slab of freestone from the quarries. A

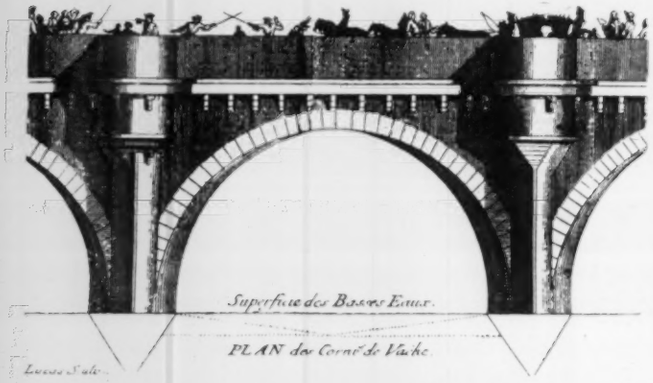


THE WAPPING END OF BRUNEL'S THAMES TUNNEL
Completed in 1843. From a Contemporary Booklet

manuscript poem (written before 1450) in the Cottonian Library in the British Museum refers apparently to certain heathen soldiers,

> That Kyllede of ye Christen, and kepten ye walles with arowes, and arblaste, and asschelers manye. (That killed off the Christians and kept the walls with arrows, and arbalists, and many ashlars.)

The Scottish Archbishop Hamilton, in the introduction



ONE OF THE LOVELY ARCHES OF THE WORLD-FAMOUS OLD PONT-NEUF IN PARIS
From Gautier's *Traité des Ponts*

to his catechism (1551), warns his readers that

> A mason can nocht heu ane euin aislair staine without direction of his rewill. (A mason cannot hew a straight ashlar stone without using his rule as a guide.)

BATTER, as applied to a wall, is something of a puzzle to philologists. It may be related to the French verb *battre*, to beat or strike repeatedly. It may be recalled in this connection that new meanings for old words sometimes develop in an unexplained way. In the Middle Ages simple ignorance was often the cause of changes in the meaning of words.

DOWEL is of doubtful derivation, although it possibly comes from the Old French *doelle*, a barrel-stave. Its origin may be Germanic. In modern German the word *döbel* has the same meaning as dowel and also signifies the plug of a cask.

GROUT meant, in German, porridge made from whole meal (we still speak, at least south of the Mason and Dixon line, of hominy grits). According to a 1713 dictionary the word meant a thick water gruel. In Doctor Samuel Johnson's dictionary (1755) coarse meal is referred to as grout, a Saxon term, which "in Scotland they call groats." Smeaton, a contemporary of Johnson, applied the term, as we do, to liquid mortar.

MASON is possibly a derivative of the Latin *machina*, meaning machine, through the French word (which sounds like the English) *maçon*. Its earlier history is obscure. Some scholars suggest that it is from the root of the Latin word *maceria*, meaning wall.

PILE is from *pilum*, which meant to a Roman the heavy javelin of a foot soldier. In a strange setting, the fourteenth century poem, "Testament of Love," the sound engineering opinion is expressed that "If the pyles ben trew, the gravel and sand wol abyde."

RIPRAP is a comparatively recent Americanism, at least in its present engineering sense. It was not in the Webster Dictionary of 1829 but appeared in that of 1848. Perhaps it comes from tide-rip and is therefore in a sense onomatopoetic. Or it may go back to the Danish *riff-raff*, meaning rubbish. The earliest use of the word yet noted was by a young Yale graduate in letters written in 1833, in which he refers to the "ripraps" opposite Old Point Comfort, meaning a breakwater then being built.

RUBBLE may have been originally Danish, from the equivalent of rubbish or waste building material.

TROWEL comes down through the French from the vulgar, or Late Latin word *truella*, for a little ladle. The classical Latin word is *trulla*.

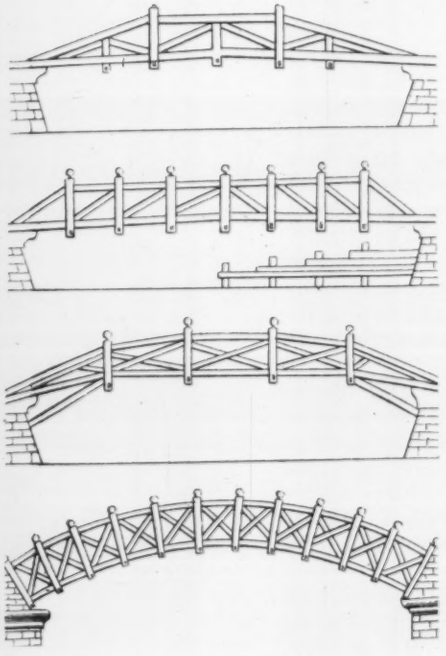
VOUSSOIR is from *volsum*, past-participle of the Latin word, *volvere*, to turn.

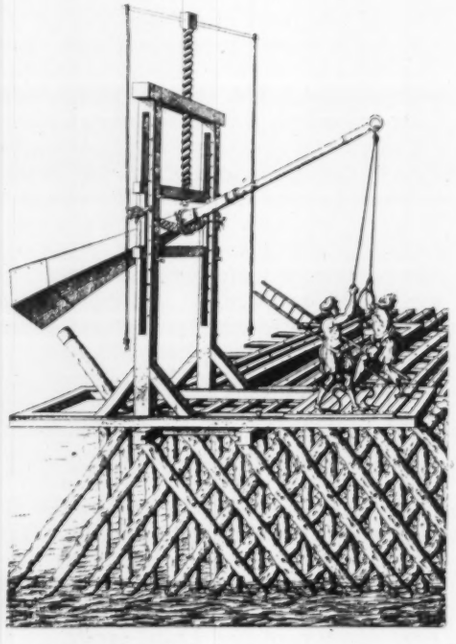
TOOLS AND APPARATUS

The word ALIDADE, meaning originally the upper arm (which revolves in its socket), comes down with only slight change from the Arabic, via Spanish and French. For centuries it denoted simply the movable arm, of an astrolabe, as Digges (the inventor of the theodolite) wrote in 1571, "Note . . . what degrees the Alhidada cutteth of the circle . . . ."

ANEROID was coined by the French, somewhat more than a century ago, from parts of three Greek words whose combined meaning is "something that does not contain fluid."

DERRICK is the surname of a noted hangman. Engineers who pass the Marble Arch, at the northeast corner of Hyde Park in London, should remember that there,





LEFT: BRIDGE TRUSSES PICTURED, AND PERHAPS USED, BY THE GREAT SIXTEENTH CENTURY VENETIAN ARCHITECT, PALLADIO (From Gautier's *Traité des Ponts*, 1728)
RIGHT: PILES AND PILE DRIVERS (From Bessons' *Theatrum Instrumentorum*, 1578)

at gruesome Tyburn, stood the first derrick. It was presided over, in the days of James I, by a certain ingenious Dutch hangman, one Derrick. Engineers of a later generation made better use of Derrick's idea, but his name has hung on.

The noun and the verb DREDGE come obviously from the Low German, *dregge*, which was used in fishing; our words drag, drudge, and dray are related terms. It is of interest to note that Doctor Johnson wrote: "To dretch in Chaucer is to delay. Perhaps a net so often stopped may be called from this."

Doctor Johnson defined a GANTRY (which he spelled "gawntry" and called "Scotish") as "a wooden frame on which beer-casks are set when tunned." The word may have come from *gaun* (tub) and *tree*. A little later a poet sang:

> At Hallowfair where brousters rare
> Keep guid ale on the Gantrees.

The engineer's word GIN, applied to many mechanical devices, has no such convivial connotations; rather it is simply a short form of the word engine. Both words may be found in Langland's great fourteenth century poem, *Piers Plowman*, where a cruel "geaunt" is described as having with a "gynne engyned," that is, with a contrivance contrived, as he fought against the forces of good.

HOIST is the past tense of an old nautical verb, *to hoise*, or raise tackle. Shakespeare has Hamlet jest, "'Tis the sport to have the engineer hoist with his own petard" (blown into the air with his own dynamite). The King James version of Acts xxvii, 40, reads as follows "They . . . hoised up the mainsail to the wind, and made toward shore."

JACK has a host of various meanings, from a playing card character to a fishing boat. Doctor Johnson quotes an apt explanation of its mechanical meaning:

> Foot-boys, who had frequently the common name of *jack* given them, were kept to turn the spit, or to pull off their master's boots, but when instruments were invented for both these services, they were both called *jacks*.

In passing it is surprising to note that a name which has descended through the Latin *Jacobus* from the original Hebrew *Jacob*, a supplanter, should be applied to something that supplants human labor. Of somewhat similar derivation seem to be the feminine *jennie* and *dolly*, applied to sundry gadgets.

Baron Napier, the inventor of LOGARITHMS, coined the word in 1614. It means literally a device for making numbers speak.

The first PENCIL was a paint brush; the Latin word was *penicillum*, a tail or small brush. Even as late as a century ago, a dictionary defined the word as "an instrument used in drawing and painting," and showed three small brushes as illustrations. Graphite, after its discovery in Cumberland, England, about the thirteenth century, was used for marking, and the thin strips were later enclosed in wood. In 1683 it was recorded, "Black lead . . . of late . . . is curiously formed into cases of Deal or Cedar and sold as dry Pencils." Incidentally the mineral graphite did not receive its present etymologically appropriate name until 1789.

A DOUBLE RAMP LEADING OUT OF A CLAY PIT AND DOWN TO THE SHORE
From Rusconi's *Architettura*, 1590

SHEAVE is from the Old English word *shive*, meaning a slice or disc.

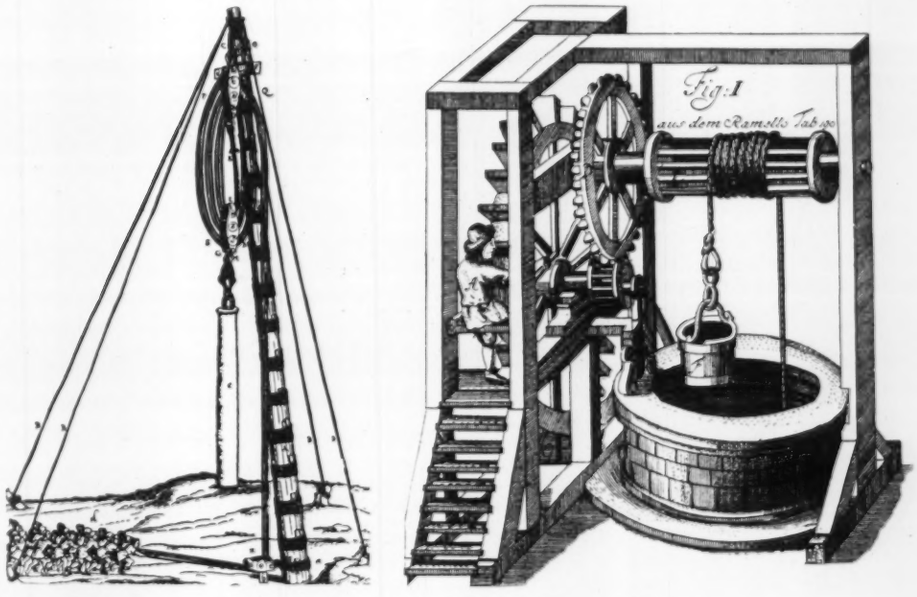
SHOVEL is Germanic in origin. The following quotation from *Piers Plowman* proves that the CWA idea existed in England a century before Columbus reached this western world:

> An heep of heremites... wenten as werkemen with spades and with schoueles and doluem and dykeden to dryve aweye hunger. (A group of hermits...went as workmen with spades and with shovels and delved and diked to drive away hunger.)

TRÉMIE is French for hopper. It is easily traced back, through the Italian, to *trimodia*, Latin for a three-peck measure.

TRUNNIONS are each of a pair of opposite gudgeons on the sides of a cannon, upon which it is pivoted on its carriage. Possibly the word is a derivative of *trognon*, a French term signifying the trunk of a tree, but its origin is uncertain.

WINCH is of Germanic origin and related to the Late Old English word, *wince*,

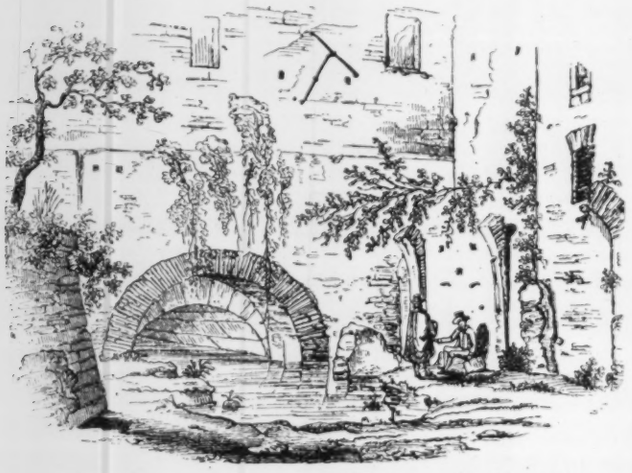


LEFT: AN ITALIAN GIN-POLE OF 1590, WHEN LABORERS WERE NEITHER FEW NOR FEEBLE (From Rusconi's *Architettura*, 1590). RIGHT: A HOIST WHICH, ACCORDING TO LEUPOLD, ONE MIGHT OPERATE ALMOST SUBCONSCIOUSLY (From His *Theatrum Machinarum Generale*, 1724)

which suggests twisting. A sixteenth century translation of Cæsar's *Commentaries* describes how "with slinges that went wyth wynches . . . and wyth pellets, they put the Galles in feare."

MISCELLANEOUS

BERM, at first a military term, was the space between the foot of a rampart and the side of the moat. The word, closely connected with brim, is found in the Ger-



THE OLDEST SEWER IN THE WORLD, THE CLOACA MAXIMA AT ROME
As Pictured by Cresy in his *Encyclopaedia of Civil Engineering*, 1847

manic languages and even in Russian and refers to the edge of a river or of the sea.

CAISSON is simply French for a large box, that is, the augmentative form of *caisse*. It has sometimes been spelled "caissoon," and its present meaning probably dates only from the time of the engineer Labelye and his greater contemporary, Perronet, about 1750.

COFFER and coffin are related; both come from the Latin *cophinus*, or the Greek *kóφivos*, a basket.

CURB was at first French. *Courbe* meant originally a curved border; then it came to mean any border, straight or curved. The concept of restraining is involved in that of curving.

DOCK is of obscure origin. Possibly it comes from the Dutch, Scandinavian, or Old French. In the fifteenth century it meant the bed made in the mud by a vessel lying at anchor in shallow water.

FILTER was at one time *felt* (the material). Both forms of the word can be traced back through the Germanic tongues to Medieval Latin.

JETTY, as its French origin, *jetée*, indicates, is something thrown out. Liquid thrown out takes the form of a jet.

The word KILN has had a curious history. Apparently it came into early English directly from the comparatively late Latin *culina*, kitchen. In some way it also entered the Scandinavian tongues, strangely, but probably by way of the English.

LEVEE is something raised; taxes are not infrequently "levied" to provide desired funds. It came into English from the past participle of the French word, *lever*, to raise.

The origin of OGEE is debatable; it may be from the Spanish, meaning a high point. The use of the word as the name of a moulding and curve is exclusively English.

PIER is apparently of unknown origin; some scholars have claimed that it comes from the Latin *petra*, rock, but this is probably not the case. It may be from the Old French word *pire* (breakwater), but this is not certainly established.

RAMP is from the Old French word, *ramper*, meaning to creep or climb. The adjective *rampant* suggests this.

SEWER in old legal phraseology meant a drain from a pond, or even a headrace. It is from the Old French *essever*, to drain off. Shakespeare spelled it *sure* and Doctor Johnson, *shore*.

SLUDGE is Germanic or provincial English, a variation of *slutch* or *slush*. It was used in England in the seventeenth century to mean a deposit of mud or mire.

TROLLEY is of course of relatively recent coinage; the term was applied a century or more ago to the low carts used by certain street merchants of Yarmouth, England. Perhaps the words *troll* and *roll* are among its collateral ancestors.

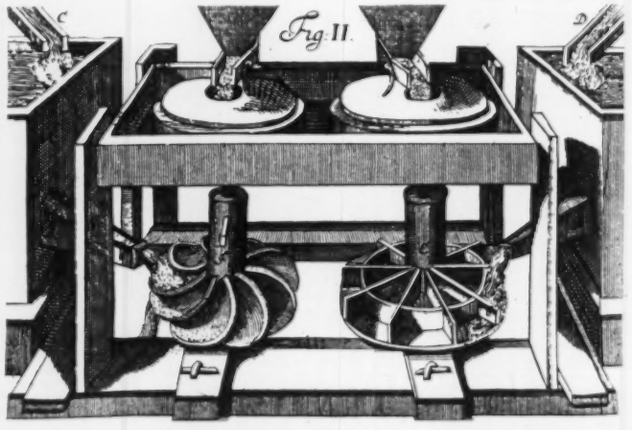
TUNNEL came through the old French, *tonel*. It is not far different in its origin from *tun*, the old word for cask. Parenthetically, a *ton* was the weight of a *tun* full of liquor.

WEIR goes back through Old English to the Germanic words for a dam or defense and eventually to a root, *wer*, meaning protect.

A group of words whose Latin origin is fairly evident includes GRADE, from *gradus*, a step; LEVEL, from *libella*, a level, diminutive of *libra*, balance; MAP, from Latin *mappa*, a napkin or tablecloth; PLUMB, from *plumbum*, lead; PROFILE, from *pro*, before, and *filum*, a line or thread; TURBINE, from *turbo*, a whirlwind, also a top (the wheel was named by a French professor, Burdin); FUNICULAR, from *funiculus*, a slender rope.

A few words have come bodily from the Latin with little or no change, such as CEMENT, CONCRETE, and CANAL. A few others of Anglo-Saxon origin are almost identical with modern Dutch, Scandinavian, or German. Among these are DAM, DIKE, LOCK, SWITCH (at first a flexible stick, but applied to little English tram roads as early as 1797).

Among the words whose origin no one seems to know



TWO ANCESTORS OF THE TURBINE
Pictured in Leupold's *Theatrum Machinarum Generale*, 1724

for certain is BOLT, which meant a heavy-headed arrow, but its origin is obscure. BOGIE, a North of England dialect word of a century ago, perhaps related to buggy, is another. PURLIN came from no one knows where; it is French in form at least. SPANDREL is another word of unknown ancestry, and so, practically, is STARLING. Finally, why are king-post and queen-post trusses so designated?

Highway Construction in Costa Rica

Extensive Program of Realignment and Grade Revision Begun by Central American Republic

By R. M. Strohl
Member American Society of Civil Engineers
Engineer and Contractor, Bowling Green, Ohio

An Aerial View of the Terrain Along the San José—Sarapiqui Road, Costa Rica
Planned to Give Access to the Rich Valley of the Sarapiqui River

PROPOSALS to construct a Pan-American Highway have focused attention on the road problem in the countries south of the Rio Grande. Costa Rica, almost equivalent in size to the combined area of New Hampshire and Vermont, initiated in 1928 a comprehensive rehabilitation of 125 miles of its road system for the use of motor vehicles. These are replacing ox carts as fast as grades and surface conditions permit. This article deals with that part of the work undertaken by a firm of North Carolina contractors, for which Mr. Strohl was in charge of engineering and construction. Power equipment was used to widen existing roads, but in wet weather on new location the pick, shovel, and wheelbarrow formed the principal excavating tools. Except for roadway width, the engineering and construction work followed standard practice in the United States. Failure of the financial plans caused the work to be shut down late in 1929, after 30 miles of road had been graded, and it has not since been resumed.

Fig. 1. Map of Projected Highway Development in Costa Rica

DURING 1928, the progressive Republic of Costa Rica attempted a highway construction program which would have been creditable to many of the states of the United States comparable in size. In its 18,400 sq miles of area, a great variety of soils and climatic conditions are found, and elevations range from sea level to over 13,000 ft. The greatest development has taken place immediately about the capital, San José, located on the high land near the continental divide. In this section, the chief products are coffee of high grade, sugar, and rice. In the past these have been transported to market by ox cart, over roads in some cases centuries old.

For many years these roads have been built of broken stone. They are mostly of the Telford type and have become rough and badly worn from traffic and rainfall. Their surface is narrow, seldom over 13 ft in width. When they were built, no studies of location were made, with the result that grades of from 15 to 20 per cent are encountered in many cases.

In 1928, when the Republic of Costa Rica decided on the construction program here described, automobile registration for the entire nation was about 1,600, exclusive of some trucks operating on the roads with the easiest grades and in the cities. The bulk of the traffic, however, was carried to market by cart, because of the roughness of roads. Highways connecting the important cities about San José were decided upon as benefiting the nation most and giving service to the large coffee plantations and to over half the population of the nation.

Contracts Granted to Two Firms

Contracts were granted to the Simmons Construction Corporation of Charlotte, N.C., and to the Cia Constructora Latino-Americano, S.A., of San José, for a total of approximately 125 miles of highway construction. The contract between the Republic of Costa Rica and the Simmons Construction Corporation, which was for 80

Construction on the Continental Divide in Costa Rica
Part of a Transcontinental Route from Limón to Puntarenas

TERRAIN TRAVERSED BY SAN JOSÉ–PURISCAL ROAD
Southwest of the Costa Rican Capital

miles of highways, provided that the latter become, in effect, a manager for its part of the project, doing all the work from the preliminary surveys to the completion of construction. This contract permitted construction to start promptly, as the detailed plans were to be prepared as construction proceeded, and the record plans as soon as convenient.

The latter part of 1928 was spent in organizing, procuring equipment, and beginning the preliminary surveys. It was necessary to import all equipment from abroad. At that time two months was the shortest time in which a shipment could be expected to reach San José because the railroad from that city to the Caribbean port of Limón had been greatly damaged by heavy rains, and all traffic was suspended for about four months. This forced all shipments to come through the Panama Canal to the Pacific port of Puntarenas, where the shallow water necessitated the use of lighters in handling all ship-to-shore movements of freight. Thus it was especially difficult to move the heavier equipment. When the railroad from San José to Limón was reopened, much better service was secured.

To the Simmons Construction Corporation three sections of highway were assigned: that from Cartago to Alajuela, 26 miles; that from San José to Puriscal, 25 miles; and that from San José to Sarapiqui, 29 miles. Of these, the Cartago-Alajuela section is the most important, being a part in the proposed transcontinental highway from Limón to Puntarenas and a possible link in the proposed Pan-American Highway. This section crosses the continental divide at an elevation of about 4,000 ft above sea level.

The road from San José to Puriscal taps a district which supplies many staple articles for the capital, a city of about 50,000 population. The terrain encountered is extremely rough, and an altitude of over 5,000 ft is reached.

The road from San José to Sarapiqui runs in a northerly direction from the Cartago-Alajuela road at its junction point at Heredia. This route was planned to give access to the rich territory in the valley of the Sarapiqui River. It crosses the continental divide between the Poas Volcano and the Barba Volcano at an altitude of 6,900 ft. The former, which is active, provides some wonderful scenery for the attraction of tourists, many of whom visit San José during the winter months. Costa Rica should benefit from the construction of the Pan-American Highway, for the climate is ideal in the highlands from about the first of December to the first of April.

As regards location, the new work followed the existing

COSTA RICAN LABORERS MAKING A HIGHWAY CUT

COSTA RICAN WORKMEN ON HIGHWAY CONSTRUCTION
Low Cost of Labor and the Daily Rains Made Mechanical Equipment Unsuited to the Work

routes as closely as practicable considering the limiting grades and curvature established. Throughout the work a maximum grade of 8 per cent was adopted for distances of not more than 660 ft, and a minimum radius of curvature of 66 ft was used. However, the maximum grade and minimum radius of curvature were not allowed together. All surveys were run using the metric system. Where it was necessary to depart from the original location, cross sections were taken and mass curves prepared for the earth work before a new location was adopted.

Construction work was started early in 1929, following the engineering work, which was carried out by two parties on preliminary surveys, one on location and one on construction. Plans for structures were made up just in advance of the construction work, and many standards were adopted from highway work in the United States,

A SECTION OF HAND-MADE COSTA RICAN ROAD

which saved an immense amount of detail. Record plans were to be worked up as soon as possible by an office force of from four to six draftsmen, following the construction work.

The pavement cross sections adopted would seem narrow in the United States, but it should be remembered that, judging by the present traffic and that to be expected in the immediate future, conditions in Costa Rica are comparable to those which obtained in the United States 20 years ago. Length rather than width was the controlling factor. For the Cartago-Alajuela road, a paved width of 18 ft was adopted, whereas for the others a width of $16\frac{1}{2}$ ft seemed ample. A shoulder width of 5 ft was adopted.

All the structures encountered were rebuilt to the adopted width. Concrete pipe was used for small openings, and concrete slabs for short spans. Concrete-beam bridges were standard for spans from 18 to 50 ft, whereas steel structures were used for spans over 50 ft long. The abutments were built of stone masonry by local masons, who were skilled in this kind of work.

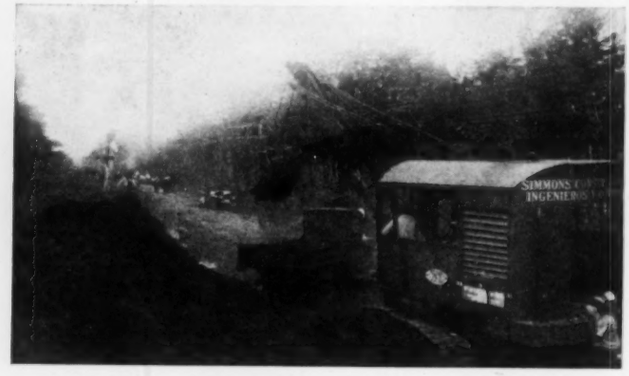
In two cases, steel structures 328 ft in length were adopted. These consisted of a center span of 164 ft and end spans of 82 ft. Steel bents were to be used at the ends of the 82-ft span, and the center span was to be erected as a cantilever. In one case, the roadway was 105 ft above the stream. Steel had been fabricated and shipped.

EXCAVATION WITH HAND TOOLS

Because of the length of the rainy season in Costa Rica, much of the grading was carried out by hand labor. Where the location departed from that of the old road, the operation of power equipment and trucks was im-

practicable on rainy days. In such cases, hand labor was employed. The Costa Rican makes an efficient laborer on work of this nature. Each individual laborer was equipped with a pick, shovel, and wheelbarrow, and

TYPICAL REINFORCED CONCRETE HIGHWAY BRIDGE, COSTA RICA



GAS SHOVEL AND TRUCKS WIDENING A ROADWAY

most of the work was on a task basis. A certain number of wheelbarrow loads, determined according to the distance the earth had to be moved, constituted a day's work, for which the laborer was paid a sum then equal to 80 cents in gold. Remarkably good results were secured, and in some cases fill could be built for 9.1 cents per cu yd. No time was lost as a result of wet grades, as a few planks for wheelways made the transportation of dirt always possible. Changing the hours of labor during the rainy season also reduced to a minimum the time lost from storm. As a general rule, even during this season, it did not rain before 2:00 p.m. By starting the day's work at 6:00 a.m., 8 hr of work was secured nearly every day before the rain set in.

Where the haul was so long as to make the wheelbarrow inefficient, resort was had to that stand-by of transportation, the ox cart. At the rates paid, this means proved economical. In some cases 50 or 60 such carts would be used per gang, and considerable quantities of earth would be moved.

Where the widening of cuts was required, a gas shovel was operated in conjunction with a fleet of trucks to move the earth. Because of the rain this method was possible only where the new location followed the old roads so that the trucks could remain on the old surface.

In 1929, at the peak of the work, 2,500 men were employed in grading, which was supervised by two superintendents who had had much grading experience in the United States.

SUITABLE STONE SCARCE

In such a rough country it would be thought that rock would be abundant and easily accessible, but such was not the case. The most difficult problem encountered was to secure enough suitable crushed stone, of which the supply in the Republic was entirely inadequate for any highway operations. There is no rock formation except at the bottom of deep gorges, and there it is covered with a heavy overburden of earth. Quarry equipment and a crushing plant having a capacity of 700 tons per day were imported from the United States and put into operation. Railroad connections with the crushing plant were established, and trucking was provided for. It was decided to ship by rail enough stone for about 30 miles of road.

In choosing the type of pavement to be laid, many factors were to be considered. The fact that all the cement had to be imported and brought by rail from the coast made the cost of concrete rather high. Plain macadam was considered impracticable because of the heavy rainfall and the lack of binding quality of the stone screenings. The temperature in the highlands is very equable, and freezing and thawing do not occur. The average temperature for the entire year is about 70 F, and the range, 10 deg. After due consideration of all these facts an asphaltic surface was decided upon.

This program of construction was well under way by the fall of 1929, when work was suspended because of the failure of the financial plans of the Republic. About 30 miles of the project had been graded and made ready for surfacing but no surfacing had been placed. Much of the work accomplished will be damaged and probably some will be wasted due to the shutdown.

On this work, R. C. Hardman, M. Am. Soc. C.E., acted in an advisory capacity for the Republic of Costa Rica, and I was in charge of the engineering and construction for the Simmons Construction Corporation.

The Republic of Costa Rica maintains a Department of Public Works and Agriculture, and the work referred to was directly under the secretary of that department.

A QUARRY FOR CRUSHED STONE
Suitable Stone for Construction Was Scarce in Costa Rica

Ordinary routine work of highway repair and the construction of bridges was under the engineer of the department. After the failure of the financial plans of the Republic, work could not proceed on such a large scale. Recently, some attempt has been made to surface some of the roadways prepared by the Simmons Construction Corporation, but such work has had to be carried out so as to keep it within the ordinary income of the government.

Improving Wisconsin Roadsides

Beautification Program Affects Design, Construction, and Maintenance

By M. W. Torkelson

Director of Regional Planning, Wisconsin Regional Planning Committee, Madison, Wis.

Higher standards for highways is the rule today. This applies to the esthetic as well as the practical or engineering features. In fact, Mr. Torkelson avers, and substantiates his claim, that beauty has decidedly a dollar-and-cents value. Wisconsin has discovered this and is putting the principle to work. Starting with the layout of its state highways and extending through to their use and maintenance, details are worked out in such manner as to conduce to the enjoyment of travelers. As indicated in this paper, the problems are not simple, but they are yielding to constructive study. As these ideals are being realized, Wisconsin's roads are gaining in utility as well as in beauty.

During the past four or five years much progress has been made in Wisconsin toward realizing the ideal of highways that are pleasing to the eye as well as serviceable and safe. To many it may seem that the beautifying of highways, so-called, is very simple, but in reality it is complex. To correct practices indulged in by highway workers that are very detrimental to the appearance of the highway—such, for instance, as the indiscriminate cutting of shrubs and flowers along the roadside—is not easy. In any large organization, such as a state highway department, procedures that have been followed for many years become fixed habits and are hard to change. The problem is not merely the modification of a few details but a fundamental change—the introduction of a totally different approach to the treatment of highways, a recognition of the fact that good appearance is essential.

Among practical road men this, in the past, has been the subject of jibes. Apropos of a practice said to be prevalent in some European countries, the planting of fruit and nut trees along the roadsides, one gentleman long-famed in highway development in Wisconsin was wont to remark that he had seen along the roadside "more nuts bearing trees than trees bearing nuts." This viewpoint is quite largely disappearing. It can be said fairly that the attitude of the highway organization as a whole, from the individual patrolman to the top, is favorable to the development of highways along lines that will make for beauty. This changed attitude has brought about a considerable amount of actual accomplishment. It can be said truly that everything done to beautify the highways has more than justified itself from the standpoint of service and safety. Utility, security, and beauty go hand in hand, and must be considered together.

Generally the word "beautify" is used to mean the operations resulting in improved roadsides. It is not satisfactory, but may be used for lack of a better term. The essentials of highway "beautification," at least as practiced in Wisconsin, are the absence of artificiality and the avoidance of ugliness. Almost any natural scenery is beautiful; it is what man does to the landscape that makes it ugly. The building of any highway involves a disturbance, but the work can be done in a way that will harmonize with the landscape and not disturb it unduly.

In order that any work done to enhance the beauty of the roadside may be effective, it is necessary that the road be built properly in the first place. It is no more possible to take a road that is inherently ugly and make it beautiful by the addition of trees and shrubs than it is to take an ill-favored human being and, by decoration with ornaments, make him or her beautiful. The quality of beauty must be inherent in the subject. In a road, this quality is largely in the character of the grading. During the early days of highway development the theory of road construction was based largely on experience with the horse and buggy. At that time modern roadbuilding machinery had not been developed, so that the cost of grading was high. Ordinary earth excavation then cost as much as solid rock does now. Roads were built in the manner that would provide the greatest length for the money available, which meant narrow roadbeds and deep ditches along the highway. Authorities tried to get along without buying any new right of way and made few changes in location unless the line of the old road was impossible.

How inadequate is this type of construction must be apparent to any one who has driven over roads built 15 or 16 years ago. Not much can be done to improve such roads without sacrificing the entire original investment.

The Sturgeon Bay—Sister Bay Road, Built in 1932
Shoulders and Ditches Seeded to Provide a Uniform Grass Cover

Shoulders Widened Without Cutting Trees
Old Ditch Filled; New Ditch Located Outside of Trees

Often it will seem necessary to remove all roadside trees. It is true that standards have gradually been raised, but it is only within the last three or four years that we have gone all the way and adopted a standard grading practice. This seems to offer reasonable hope that the development of our highways can be continued simply by adding to what there is, whenever an increase in highway capacity becomes necessary, and without tearing out anything.

The Rocky Arbor—A Picturesque Wisconsin Roadside Maintained in Its Original State

A View Just Beyond the Rocky Arbor—What It Would Have Become in Private Ownership

AN EXAMPLE OF NATURAL BEAUTY PRESERVED BY STATE OWNERSHIP

These standards call for the following two main requirements:

1. The roadbed must be of such width that the shoulders outside the paved or traveled part will afford safety for pedestrians or for people who wish to stop by the roadside outside the main stream of traffic. On most main roads in Wisconsin a roadbed 40 ft wide is being built, which provides for a 20-ft pavement with a 10-ft shoulder on each side (Fig. 1). This also permits horse-drawn traffic to proceed safely outside the main stream. There is nothing more likely to cause an accident than a farm wagon driving on a paved highway in the dusk. The wide shoulders are generally surfaced to encourage horse-drawn traffic to use them. The outer edges of the shoulders should be kept smooth for pedestrians. A sidewalk at the outer edge of the right of way does not seem practicable except in and near cities.

2. The roadbed must be of such height that snow can be readily removed during the winter. This height is to be built up using excavated material from some outside source. Generally it is taken from ditches along the roadside and graded up in the center. Former practice was to make these ditches deep and narrow, with steep slopes; modern practice is to make them wide and shallow, with very gradual, easy slopes.

It will readily be perceived that the three purposes of utility, beauty, and safety are inseparable, since the wide roadbed with gentle slopes and shallow, wide ditches tends toward safety and best serves utilitarian purposes, at the same time being most favorable for the planting and care of vegetation for the decoration of the roadside. The deep, narrow ditches characteristic of the former type of grading are subject to erosion. Furthermore, the scars left by such grading do not readily grass themselves, and if they do, they cannot be mowed except by hand, which is expensive and leaves a ragged appearance. With the new type of grading, the roadside can readily be kept trimmed by machinery and made to look neat and attractive at low cost. During the dry season of 1934, farmers mowed hay in some places where the grading was of the new type.

Such grading requires a wide right of way, in general a minimum width of 100 ft. In many cases the right of way is 120 ft, and even more where land is cheap and covered with timber. Such widths also assure that plantings and volunteer growths will have a reasonable opportunity to grow undisturbed.

Every time the State Highway Commission builds along an existing road, in the long-settled parts of the state, it must deal with rows of trees set too close in. Some of these have been planted less than ten years and are now growing thriftily, but often they must be moved farther out before improvements that are already pressing can proceed.

In some cases it is possible to save existing growth along the fences by grading the ditch outside the tree line on the widened right of way. In such cases, as shown in Fig. 2, the original ditch is filled and the shoulder sloped gradually to the ditch outside the tree line. The appearance of old grading can be improved greatly by using loose stone dumped from fields into the road to widen embankments.

BENEFITS ACCRUE FROM REALIGNMENT

Generally the location of main roads is fixed so that little if anything can be done to improve the appearance by changing the alignment. Occasionally, however, where it becomes necessary to change a location, there are possibilities of improvement. Two cases serve as illustrations of what has been done.

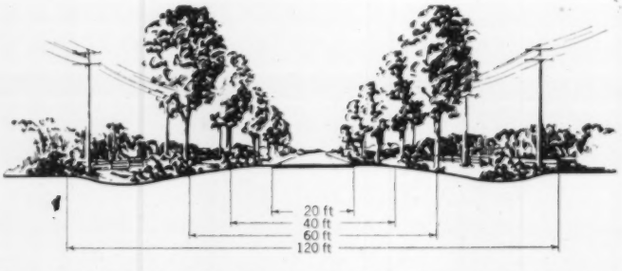


FIG. 1. IDEAL SECTION FOR A TWO-LANE CONCRETE PAVEMENT
This Grading Is Actually Used on Roads of Greatest Importance

In the construction of State Trunk Highway No. 29, between Shawano and Wittenberg, Wis., it became necessary to relocate the highway to secure proper alignment. The new line is through a very beautiful timbered tract, principally hard maple. Here the Highway Commission purchased a right of way 600 ft wide in order to preserve the fine timber. The grading was carried out in such a way that none of the trees was cut except within the ac-

tual earthwork. Unless a forest fire or some other cause beyond control intervenes to destroy this timber, it will be preserved for the enjoyment of the passer-by.

The other instance is on U. S. Highway No. 12 in Juneau County. This is one of the main arteries of travel from Chicago, Milwaukee, and all southeast Wisconsin to La Crosse, Eau Claire, St. Paul, and Minneapolis. The last section to be paved was just northwest of Wisconsin Dells, formerly known as Kilbourn. The location of this 11-mile section was under consideration by the Wisconsin Highway Commission for three or four years before construction. Various survey lines were run, none of them very satisfactory. Early in 1932 a further reconnaissance was made along a different route, which presented such advantages that it was immediately approved by the Commission for construction.

For a distance of about three-quarters of a mile this route traverses a rocky gorge of unusual beauty, whose local name is the "Rocky Arbor." It is an old bed of the Wisconsin River, a bit of the Dalles scenery, with rocky crags overgrown with pine and birch and oak—something unique and unsurpassed in beauty. It has survived devastation largely because of its inaccessibility. In one way it seems a pity that a main artery of travel should be located through such a place. Yet it is the logical route for the road—the line of least resistance. The Commission felt that steps should be taken to preserve it and began casting about for ways of doing so. Luckily the means were available. The Legislature of 1929 appropriated $10,000 to the Conservation Commission for the purchase of forest land abutting on state trunk highways, and some of the money was still available. When the Rocky Arbor project was presented to the members of this commission, they became just as enthusiastic as the Highway Commission; therefore steps were taken to acquire this scenic gem for the people.

Grading through the Rocky Arbor was designed to disturb the natural landscape as little as possible. It was necessary to make deep cuts at each approach, but in the bed of the gorge the roadbed is entirely in embankment, with such gentle slopes that it can scarcely be distinguished from the natural topographical features. The rocky cliffs were left undisturbed; the trees outside the grading area were not cut. Luckily the topography permitted excellent alignment. In the winter of 1933–1934 a CCC force was employed in cleaning out dead and fallen timber and cutting dead branches near the roadway. No further attempt at "beautification" has been made.

Old-Style Grading, with Steep Slopes and Sharp Corners; Erosion in Back Slope and in Ditch Still Active After Six Years

After Revision by CWA Forces; Back Slope and Ditch Covered with Top Soil and Seeded to Control Erosion

IMPROVING RIGHT OF WAY BY FLATTENING BACK SLOPE AND ROUNDING EDGES

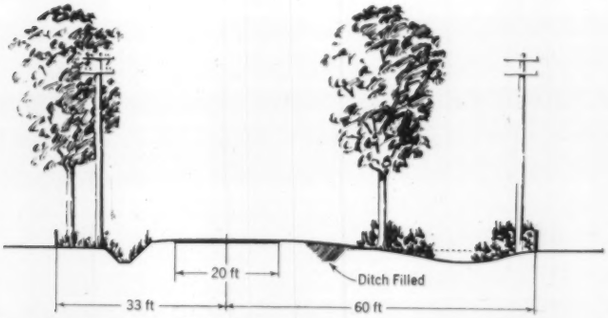


FIG. 2. OLD-STYLE GRADING SECTION (LEFT) AND SECTION AS REVISED (RIGHT) TO WIDEN SHOULDER WITHOUT SACRIFICING EXISTING ROADSIDE GROWTH

MAINTENANCE METHODS AFFECT BEAUTIFICATION

In addition to so modifying construction as to greatly improve the appearance of the highways, the Highway Commission is adopting maintenance practices to prevent the destruction of that roadside beauty which naturally exists. The first and most important is the laying of dust on main roads. Nothing is more destructive to vegetation—which is the principal basis of roadside beauty—than the pall of dust hanging along every heavily traveled gravel road. It is a source of danger to travel and must make life almost insufferable to those who live along the road. Experience with road oil indicates that it contributes benefits in addition to those immediately sought. Not the least of these extra advantages has been improved appearance, through the absence of the dust which formerly weighed down foliage and gave the entire roadside an appearance of desolation.

The State Highway Maintenance Department is also making a sincere effort to prevent the cutting of trees and shrubs whose presence adds to the beauty of the highway. Every fall preparations are made to remove snow from the main roads. Generally, the trouble is not caused by the snow that actually falls on the road but by that which drifts on. Some of the most prevalent causes of snowdrifts are growths of weeds and brush, so located that drifts form along their leeward sides on the traveled way. To prevent this it has been the practice for the regular maintenance forces to remove the offending vegetation each fall. In some cases they have not exercised much discrimination but have swept the roadside clear of everything. This has resulted in deserved criticism. The maintenance engineer, however, has issued strict orders designed to secure the cutting of only what ought to be removed and the preservation of what reasonably can be left.

In connection with the snow-removal problem, the Commission is making an experiment with a view to utilizing a thing of pure utility for the improvement of the roadside. The familiar but ugly lath-and-wire snow fence, set up every fall and taken down in the spring, costs about $275 per mile per year to erect and maintain.

AN EVERGREEN SNOW FENCE. PAVED ROAD JUST TO LEFT OF TREE IN LEFT CENTER

The Commission has considered that it might, in certain places, acquire the land on which such a snow fence would be set up and plant a thicket of evergreens, which when grown would be just as effective in preventing snowdrifts and at the same time would constitute a permanent ornament to the highway. Some experimental plantings of snow hedges have been made, but it is too early yet to judge the results. The practicability of this plan depends largely on the cost of the land needed. It is known that evergreens tend to die out rather easily in dry times. Deciduous shrubs with compact habits of growth may prove more drought-resistant and equally effective. Still there is nothing so striking as evergreens against the snows of winter.

Theoretically, if it costs $275 per year to maintain a mile of lath-and-wire fence, this will justify a capital investment of about $4,000 or $4,500 to place a permanent fence not requiring maintenance. Practically, to attempt to carry out a large program of this kind where land is valuable would require such a large initial expenditure that it could scarcely be financed. However, a mile of permanent snow hedge along a state trunk highway is worth just as much in the way of service in the northern part of the state, where the cost of land is low, as in the southern, where the land is high, and perhaps even more, because in the north the snow and drift conditions are worse than in the south.

In this upper part of the state large tracts of wild land covered with trees and bushes have come into county ownership through tax delinquency. The Commission is making an effort to induce the county authorities to dedicate strips of wooded land along state trunk highways, of a sufficient width so that all drifting of snow on the highways will be prevented. Naturally, this also will result in preserving all the vegetation and natural beauty. Wherever the subject has been broached it has met a cordial response. The Commission has also authorized purchases of cheap land covered with trees and brush in certain instances. The amount necessary to maintain a mile of snow fence, if spent for land at $25 per acre, would buy a strip 90 ft wide, which is ample for a windbreak. It seems highly desirable to acquire as much of this land as is reasonably possible at prevailing low prices.

BEAUTIFICATION ON A SOUND BASIS

So far, the discussion has pertained to work primarily designed for utility, with beauty as a by-product, so to speak. Although highway construction and maintenance must be carried out mainly for utilitarian reasons, this work should be done so as to provide a sound foundation for future "beautification." Some work has been done purely for beautification. For years certain county highway commissioners, largely on their own initiative, have been planting trees and shrubs along the roadside, mostly on small triangular tracts at highway intersections. They have been encouraged to continue in work of this character. The Commission has also cooperated with local authorities.

A number of other projects have been undertaken, one of which will be mentioned. It was suggested by the Federation of Women's Clubs of one of the northern counties and involved the improvement of an important U. S. highway across the county, using the lilac as the principal feature of the planting. The purpose was to honor the pioneer women who brought the lilac with them to plant around their homes. As a result, the sum of $2,500 was provided by the Commission, and the plan, in cooperation with the Department of Horticulture at the University of Wisconsin, was carried out the next spring, largely as a research project.

IDEALISM PUT INTO PRACTICE

In Wisconsin the underlying idea of highway beautification has been to avoid ugliness. The ideal for major highways is a road that will be up to the minute in safety and usefulness and that will harmonize with the landscape, the roadside being mowed as far as the ditches and the space beyond left with the trees and shrubs native to the locality growing in profusion as Nature would have them. The most important positive act has been the adoption of grading practices designed to give the

A FARMER'S FRONT YARD
Ditches Not Needed for Drainage Detract from Beauty

landscape architect ample opportunity to function without the necessity of first rebuilding the road. Under such conditions Nature, the greatest of landscape architects, will do a good job in Wisconsin if given a few years of time. Such grading practices make it possible to add a third or fourth traffic lane without interfering with the original pavement or with any planting or volunteer growths. Telephone and power transmission lines can and should be beyond the trees, where they cause no interference and where their gaunt outlines are subdued. It does not seem possible to get rid of them.

Adequate rights of way, 100 ft or preferably 150 ft wide, need not be absolutely uniform. If extra width would do violence to a farmer's front yard, a special ditch and slope section may be used at this point so as to leave the farmer in possession. After all, the flower beds, shrubs, trees, and other plantings in his front yard improve the highway just as much as though they were planted with highway funds.

For appearance, cuts and fills should join the natural ground surface by easy curves, avoiding the sharp straight lines generally used. Perhaps contracts should include nothing more than rough grading, leaving the finish to be done by day labor with no calculation of yardage. The humus-bearing top soil should be conserved; kept out from under the pavement, where it is a detriment; and spread over the side slopes, ditches, and back slopes, where it will be a benefit. There it will provide the basis for grass, which not only will "beautify" the roadside but, what is still more important, effectively scotch that great destroyer, erosion.

EMPHASIS PLACED ON PRESERVATION OF EXISTING GROWTH ALONG ROADSIDE

No great emphasis has yet been placed on planting. Rather the emphasis has been to preserve what exists and to create conditions favorable to increased growth. There is nothing finer than a well-cultivated field—right up to the roadside. Still, some planting has been done, all under the direction of a man trained in landscape architecture. The character of the work has been various; generally the design has been to simulate nature, although in a few cases where it seemed appropriate, we have followed the practice of our ancestors by planting trees in rows evenly spaced.

TRAVEL THROUGH PLEASANT SURROUNDINGS
Nothing Finer Than a Cornfield Grows Along a Roadside

If there had been a slogan it would have been "Clean up the roadside." Any rubbish or trash within sight of the road is ugly; its absence generally leaves the landscape beautiful. Brush piles, rock piles—even auto dumps—can be removed. An unkempt, ill-kept residence along the highway is ugly and hard to get rid

ROAD INTERSECTION TRIANGLE—NO MAINTENANCE NEEDED EXCEPT TO PRESERVE EXISTING GROWTH

of. It seems, however, that order is contagious, so that when the road is built and tidied up, the neighbors follow suit as to their premises; at least such has been our experience.

The hot dog stands and filling stations that seem to be such an offense in the East do not greatly trouble us. The billboard, however, remains our most difficult problem. Although it was banished from the highway limits long since, its presence just over the fence is not much different in so far as it affects the esthetic sense. From this standpoint its offense is that it is out of place in the country, as kerosene would be in a salad.

The organized outdoor advertising industry vigorously condemns "tacks" and "snipes," which have no care or upkeep, insisting that it meets all reasonable requirements if its "bulletins" and "panels" are well constructed and maintained, and its advertising is not offensive to morals. In this it falls far short of the ideals of the organized groups advocating roadside improvement. The general public seems rather apathetic. The industry has expressed itself as agreeable to zoning regulation that would apply to all business in the locality, but objects vigorously to regulation applying to outdoor advertising only.

While regulatory legislation was introduced in the Wisconsin legislatures of 1929, 1931, and 1933, it was all killed in committee. Other states have attempted statutory regulation, some based on the zoning principle, some on taxation, but none that seems to have met with any great success. It appears unlikely that regulation can be successful until demanded by public opinion to a much greater degree than at present. In the meantime the work of highway "beautification" in Wisconsin will have to proceed along the lines that have brought us such success as we will presently have attained, leaving the abolition of the rural billboard to such time as an esthetically educated public will demand it.

ENGINEERS' NOTEBOOK

From everyday experience engineers gather a store of knowledge on which they depend for growth as individuals and as a profession. This department, designed to contain practical or ingenious suggestions from engineers both young and old, should prove helpful in the solution of many troublesome problems.

Real Estate Survey for Assessment Purposes

By WYATT E. WILLIAMS, JUN. AM. SOC. C.E.
PETERSBURG, VA.

IN these last few years of depression many cities and municipalities have found need for an assessment system that will give the assessor accurate working information regarding the properties he is to assess. There can be no doubt that the guesswork system of the past is outmoded; something must take its place, and it is

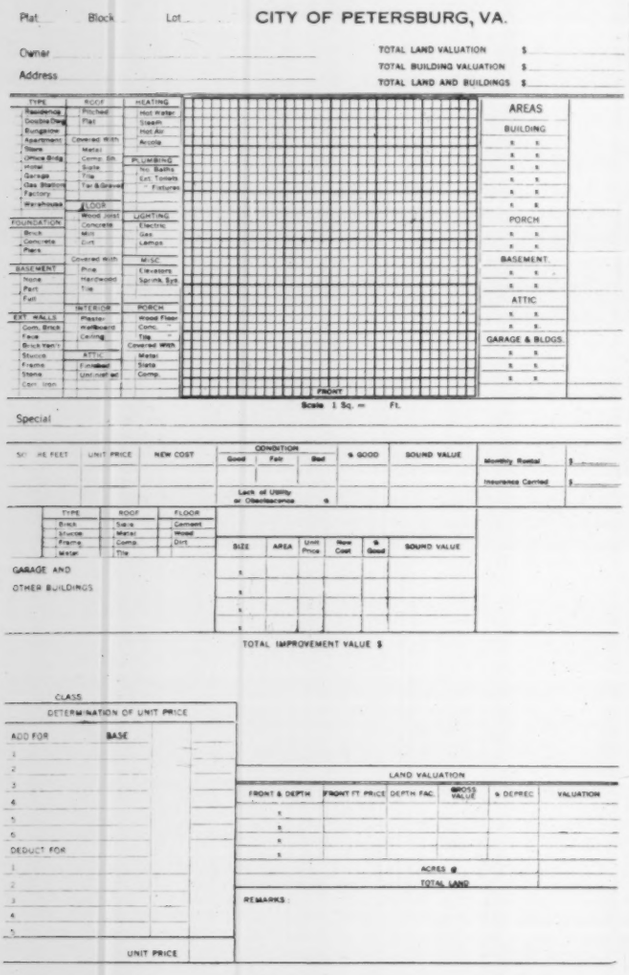


FIG. 1. WORK SHEET FOR VALUATING RESIDENTIAL PROPERTY IN PETERSBURG, VA., FOR ASSESSMENT PURPOSES

largely up to the engineer to supply it.

Such a system has been put in effect in Petersburg, Va., a city of approximately 30,000. In the spring of 1933 the City Council and H. A. Yancey, M. Am. Soc. C.E., the city manager, decided to make a real-estate survey for the purpose of gathering data on which to base the 1934 assessment. The first step was to create an organization for this purpose, so the entire job was let on contract to a local architect, a man of proved ability with a good working knowledge of local conditions. He selected his own staff, consisting of a local contractor who worked on the classification details with him, two field survey parties of two men each, and a clerk for stenographic and filing work in the office. A surveyor was employed on a part-time basis to run lines on the land where plats were either lacking or inadequate.

PRELIMINARY CLASSIFICATION

The preliminary procedure, begun late in May of 1933, was a classification of buildings, the results of which are shown in Table I. This classification was intended primarily to cover residences. First, a general division into one and two-story buildings was made. Each of these in turn was subdivided, according to type, into brick, brick veneer, stucco, and frame. The next step was to select a standard house of each type. For each of the standard types selected, plans were obtained and the replacement costs determined by the contractor, who made allowance for fluctuation in the prices of materials in the rising market. Then the base price, or price per square foot, was calculated and the other values in the table determined. Finally the value of the extra facilities and fixtures in the structures was computed, and the results are shown in the third part of Table I. The next step was to formulate the work sheet illustrated in Fig. 1, which was to be used by the field parties in taking actual data. A permanent record sheet similar to the form shown in Fig. 1 was developed and kept on file for the future use of the assessors.

When this preliminary work was completed, the field work began. Party No. 1, equipped with the work sheets and a tape line, preceded Party No. 2. This group had the task of checking the exterior details of the building, particularly the type, foundation, exterior walls, roof, and porches, and of recording these data on the form. They next measured around the building and plotted a drawing to scale in the cross-section space provided. The building and porch areas were computed, and the percentage of porch space determined. This party also checked the size of the lot.

INTERIOR FEATURES CHECKED AND CLASS OF STRUCTURE DETERMINED

At the end of the day the work sheets were turned over to Party No. 2, consisting of the architect in charge and a man experienced in real estate, who checked the interior features, including finish, size of basement and attic, and heating and plumbing. They also determined in which class the structure belonged, such as Brick No. 1, Stucco No. 1*a*, or Frame No. 2. After the class of the structure was established, it could be seen by reference to the work sheet whether the building had more or less equipment than the standard for the structure required.

The base price taken from Table I was entered in the allotted space at the lower left of the form reproduced in

TABLE I. REPLACEMENT COSTS OF RESIDENCES IN PETERSBURG, VA., IN UNITS OF SQUARE FEET OF FLOOR PLAN

MATERIALS FOR ONE-STORY HOUSES	BASEMENT							FLOORS					HEATING				ROOFING			
	Base	Porch 10%	20%	40%	60%	80%	Full	Attic 10%	Hard-wood 1/3	Hard-wood 2/3	Tile 10%	Double Floors	Hot Air	Pipeless	Hot Water or Steam	Arcola	Slate	Tile	Metal	Comp.
Brick:																				
No. 1 (13-in. wall)	3.50	.20	.22	.32	.42	.52	.60	.08	.01	.02	.07	...	−.04	−.09	...	−.03	...	.24	−.09	−.15
No. 1a 13-in. wall / 9-in. wall	2.95 / 2.75	.20	.22	.32	.42	.52	.60	.08	.01	.02	.07	...	−.04	−.09	...	−.03	...	.24	−.09	−.15
No. 2 (9-in. wall)	2.62	.16	.22	.32	.42	.52	.60	.08	.01	.02	.07	.03	.20	.15	.24	.21	.09	.33	...	−.06
Brick Veneer:																				
No. 1	3.05	.20	.20	.30	.39	.48	.56	.08	.01	.02	.07	...	−.04	−.09	...	−.03	...	.24	−.09	−.15
No. 1a	2.80	.20	.20	.30	.39	.48	.56	.08	.01	.02	.07	...	−.04	−.09	...	−.03	...	.24	−.09	−.15
No. 2	2.45	.16	.20	.30	.39	.48	.56	.08	.01	.02	.07	.03	.20	.15	.24	.21	.09	.33	...	−.06
Stucco:																				
No. 1	2.88	.20	.18	.28	.36	.44	.50	.08	.01	.02	.07	...	−.04	−.09	...	−.03	...	.24	−.09	−.15
No. 1a	2.65	.20	.18	.28	.36	.44	.50	.08	.01	.02	.07	...	−.04	−.09	...	−.03	...	.24	−.09	−.15
No. 2	2.28	.12	.18	.28	.36	.44	.50	.08	.01	.02	.07	.03	.20	.15	.24	.21	.09	.33	...	−.06
Frame:																				
No. 1	2.80	.20	.18	.28	.36	.44	.50	.08	.01	.02	.07	...	−.04	−.09	...	−0.3	...	.24	−.09	−.15
No. 1a	2.58	.20	.18	.28	.36	.44	.50	.08	.01	.02	.07	...	−.04	−.09	...	−0.3	...	.24	−.09	−.15
No. 2	2.18	.12	.18	.28	.36	.44	.50	.08	.01	.02	.07	.03	.20	.15	.24	.21	.09	.33	...	−.06
No. 3	..	.12	...	...	...	...	...	...	...	...	...	...	...	...	...	...	.09	.33	...	−.06
No. 4	..	.10	...	...	...	...	...	...	...	...	...	...	...	...	...	...	.09	.33	...	−.06

MATERIALS FOR TWO-STORY HOUSES	BASEMENT							FLOORS					HEATING				ROOFING			
	Base	Porch 10%	10%	20%	30%	40%	Full	Attic 10%	Hard-wood 1/3	Hard-wood 2/3	Tile 10%	Double Floors	Hot Air	Pipeless	Hot Water or Steam	Arcola	Slate	Tile	Metal	Comp.
Brick:																				
No. 1 (13-in. wall)	3.30	.20	.11	.16	.21	.26	.30	.07	.01	.02	.07	...	−.04	−.09	...	−.03	...	.14	−.05	−.08
No. 1a 13-in. wall / 9-in. wall	3.00 / 2.80	.20	.11	.16	.21	.26	.30	.07	.01	.02	.07	...	−.04	−.09	...	−.03	...	.14	−.05	−.08
No. 2 (9-in. wall)	2.40	.16	.11	.16	.21	.26	.30	.07	.01	.02	.07	.03	.20	.15	.24	.21	.05	.19	...	−.03
Brick Veneer:																				
No. 1	2.85	.20	.10	.15	.20	.24	.28	.07	.01	.02	.07	...	−.04	−.09	...	−.03	...	.14	−.05	−.08
No. 1a	2.61	.20	.10	.15	.20	.24	.28	.07	.01	.02	.07	...	−.04	−.09	...	−.03	...	.14	−.05	−.08
No. 2	2.25	.16	.10	.15	.20	.24	.28	.07	.01	.02	.07	.03	.20	.15	.24	.21	.05	.19	...	−.03
Stucco:																				
No. 1	2.70	.20	.09	.14	.18	.22	.25	.07	.01	.02	.07	...	−.04	−.09	...	−.03	...	.14	−.05	−.08
No. 1a	2.46	.20	.09	.14	.18	.22	.25	.07	.01	.02	.07	...	−.04	−.09	...	−.03	...	.14	−.05	−.08
No. 2	2.10	.12	.09	.14	.18	.22	.25	.07	.01	.02	.07	.03	.20	.15	.24	.21	.05	.19	...	−.03
Frame:																				
No. 1	2.64	.20	.09	.14	.18	.22	.25	.07	.01	.02	.07	...	−.04	−.09	...	−.03	...	.14	−.05	−.08
No. 1a	2.40	.20	.09	.14	.18	.22	.25	.07	.01	.02	.07	...	−.04	−.09	...	−.03	...	.14	−.05	−.08
No. 2	2.00	.12	.09	.14	.18	.22	.25	.07	.01	.02	.07	.03	.20	.15	.24	.21	.05	.19	...	−.03
No. 3	..	.12	...	...	...	...	...	...	...	...	...	...	...	...	...	...	.05	.19	...	−.03
No. 4	..	.10	...	...	...	...	...	...	...	...	...	...	...	...	...	...	.05	.19	...	−.03

To Be Added for Extra Facilities and Fixtures

Sq Ft in Structure	Common Brick	Storm Siding	Bath Tile	Bath Plaster & Wood	Toilet & Lav. Tile	Fixture Plaster & Wood	Toilet: House	Toilet: Basement
1,000	.08	.06	.36	.24	.24	.04	.07	.04
1,500	.07	.05	.24	.16	.16	.03	.05	.03
2,000	.06	.04	.18	.12	.12	.02	.03½	.02
2,500	.06	.04	.15	.10	.10	.01½	.03	.01½
3,000	.05	.03	.13	.08	.09	.01½	.02½	.01½
3,500	.05	.03	.11	.07	.08	.01½	.02	.01
4,000	.04	.03	.10	.06	.07	.01	.02	.01
4,500	.04	.03	.09	.05	.06	.01	.01½	.01
5,000	.04	.03	.08	.05	.06	.01	.01½	.01

Fig. 1. Additions to this base price for extra facilities or deductions for the lack of such improvements, as the case may be, were made. These additions and deductions are also shown in Table I. The sum total or unit price was then multiplied by the area of the structure in square feet to obtain the new cost. Party No. 2 also passed on the condition of the building, as determined by age, surroundings, and general appearance, and a sound estimate of the value of the property was finally made. Using a special set of base costs, the same process was followed for the garages and sheds. Thus the total improvement value of the property was accurately obtained.

As the final step, a clerk in the office transcribed the data from each work sheet to a permanent record sheet and filed them by streets and numbers. As an additional precaution and to add flexibility to the system, the new unit price and costs were not filled out on the permanent record sheets so that, should it appear later that insufficient allowance had been made for fluctuating price indices, the change would entail a minimum amount of labor. When the industrial and business districts of the city are reached, appropriate bases will be worked out for them too.

A Slide Rule for Cubic Equations

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THAT there is general interest in methods of solving cubic equations is shown by the numerous articles on the subject that have been published in the past. Where

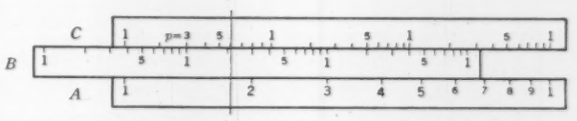

FIG. 1. A SLIDE RULE FOR SOLVING CUBIC EQUATIONS

the solution of such equations is frequently necessary, a slide rule method seems to offer the advantages of simplicity and directness. A slide rule of three logarithmic

scales, as shown in Fig. 1, can be made by using logarithmic paper. For the two three-cycle scales, B and C, Codex paper No. 3212 is suitable, and for the single-cycle scale, A, Codex paper No. 4234 may be used.

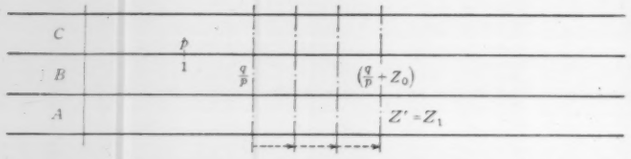

FIG. 2. ILLUSTRATING METHOD OF USING THE SLIDE RULE TO SOLVE CUBIC EQUATIONS

These may be glued to stiff material to form a slide rule. A slide indicator will give numbers on the C-scale, under the hair line, that will be the cubes of the corresponding numbers on the A-scale.

With this slide rule, in order to solve the general cubic equation,

$$ax^3 + bx^2 + cx + d = 0 \quad . \quad . \quad . \quad . \quad . \quad [1]$$

it is first necessary to transform the equation by eliminating the x^2 term and to put it in a form suitable for solution by slide rule. This transformation is made by letting $x = Z - \frac{b}{3a}$. The equation then takes the form,

$$Z^3 + pZ + q = 0 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [2]$$

the roots of which will satisfy the relation,

$$Z_1 + Z_2 + Z_3 = 0 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [3]$$

To solve the transformed equation by means of the slide rule, it is put in the form:

$$Z^3 = -(q + pZ) = -p\left(\frac{q}{p} + Z\right)$$

or

$$Z = \sqrt[3]{-p\left(\frac{q}{p} + Z\right)} \quad . \quad . \quad . \quad . \quad . \quad . \quad [4]$$

To distinguish between the Z in the left member and the Z under the radical sign, this relation is written in the form,

$$Z' = \sqrt[3]{-p\left(\frac{q}{p} + Z_0\right)} \quad . \quad . \quad . \quad . \quad . \quad [5]$$

To obtain a real root of the equation, set the index of the B-scale under the value of p on the C-scale and the hair line of the indicator on the value of $\frac{q}{p}$ on the B-scale, using the proper cycle; then move the indicator along the B-scale by some assumed value of Z_0. Compare this number with the number under the hair line on the A-scale, which is the value of Z' for the assumed value of Z_0, which indicates whether Z is greater or less than the amount assumed for Z_0. When Z' and Z_0 are of the same sign and Z' is greater than Z_0, the indicator must be moved in such a direction as to increase Z_0, but if Z' is less than Z_0, the indicator must be moved in such a direction as to decrease Z_0. By successive small shifts of the indicator, values are found such that the number on the B-scale minus $\frac{q}{p}$ equals Z'. Then $Z' = Z_0 = Z_1$. The slide rule setting is as shown in Fig. 2. This gives the first real root of the transformed equation, and by the relation, $x_1 = Z_1 - \frac{b}{3a}$, the value of this root for the given equation can be found. If the remaining two roots are complex, they can be found by factoring the transformed equation and solving the quadratic term.

It is important to notice that a root equal to $-\frac{q}{p}$ cannot be found directly by means of the slide rule, but if there are three real roots, it can be found by the relation,

$$Z_1 + Z_2 + Z_3 = 0 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [6]$$

after two roots have been obtained. The following numerical example is given in detail to illustrate the method.

To obtain the roots of the cubic equation:

$$x^3 - 12x^2 + 45x - 53 = 0$$

Let

$$x = Z - \frac{(-12)}{3} = Z + 4$$

Substituting for x,

$$(Z + 4)^3 - 12(Z + 4)^2 + 45(Z + 4) - 53 = 0$$

$$Z^3 + 12Z^2 + 48Z + 64 - 12Z^2 - 96Z - 192 + 45Z + 180 - 53 = 0$$

The transformed equation is,

$$Z^3 - 3Z - 1 = 0$$

$$Z' = \sqrt[3]{3(0.333 + Z_0)}$$

Set the index of the B-scale under the value of $p = 3.0$ on the C-scale, using the proper cycle, as shown in Fig. 1. The value of Z_0 is then varied, as has been explained, until the value of Z' is equal to the number on the B-scale minus 0.333, or 1.87, which is a real root of the transformed equation. The number under the hair line on the B-scale equals 2.203, as shown in Fig. 3.

To obtain another real root, two other values must be found on another part of the scale, or if there is a negative root, Z_0 is considered to be minus, which in this

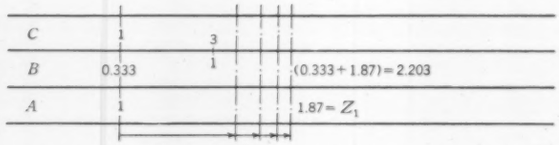

FIG. 3. SOLUTION OF A NUMERICAL EXAMPLE OF A CUBIC EQUATION BY SLIDE RULE

case gives -1.207 on the B-scale and -1.54 on the A-scale, which is the second root, Z_2, of the transformed equation. The third root can be quickly obtained by the relation,

$$Z_1 + Z_2 + Z_3 = 0, \quad \text{or } Z_3 = -0.33$$

Since Z_3 has a value substantially equal to $-\frac{q}{p}$, this root cannot be found directly by means of the slide rule. The roots of the given equation are:

$$x_1 = Z_1 + 4.0 = 1.87 + 4.0 = 5.87$$

$$x_2 = Z_2 + 4.0 = -1.54 = 4.0 = 2.46$$

$$x_3 = Z_3 + 4.0 = -0.33 + 4.0 = 3.67$$

This example will indicate the simplicity with which cubic equations can be solved by means of a desk-made slide rule.

Concrete Design for Bending and Direct Stress

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WITH the development of frame analysis and the use of rigid-frame structures, the up-to-date designer has been confronted with new problems. One of the most important of these is the proportioning of members subjected to bending and direct stress, and having tension over part of their controlling cross sections. A method of attacking this problem, which has proved satisfactory in a design office, is presented here.

A typical cross section having tensile steel in one face and no compressive steel required in the other is represented by Fig. 1. Discussion of the method will be limited to the rectangular cross section, and the nomenclature will be as indicated on the accompanying figures.

Taking moments about the tensile steel,

$$Ne_1 = \frac{f_c k j b d^2}{2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [1]$$

Or, since

$$f_c = \frac{k f_s}{n(1-k)}, \text{ and } j = 1 - \frac{k}{3},$$

$$N \frac{6ne_1}{f_s b d^2} = \frac{k^2 (3-k)}{1-k} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [2]$$

Substituting for k its value of $\dfrac{1}{\dfrac{f_s}{nf_c} + 1}$,

$$N \frac{6ne_1}{f_s b d^2} = \frac{1}{\dfrac{f_s}{nf_c}} \times \frac{\dfrac{3f_s}{nf_c} + 2}{\left(\dfrac{f_s}{nf_c} + 1\right)^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [3]$$

In Table I are found values of k, j, and $\dfrac{f_s}{nf_c}$ corresponding to given values of $N \dfrac{6ne_1}{f_s b d^2}$.

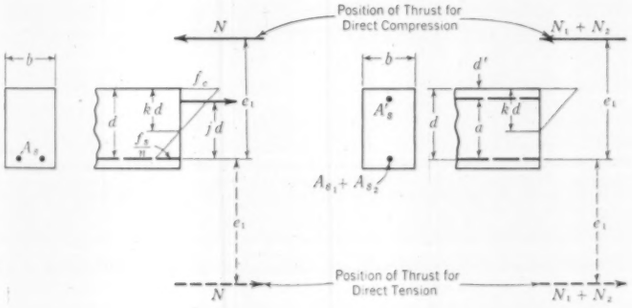

FIG. 1. (LEFT) SECTION REQUIRING NO COMPRESSIVE STEEL
FIG. 2. (RIGHT) OBTAINING AREA OF COMPRESSIVE STEEL

To determine whether compressive steel is needed, compute the value of $\dfrac{N}{f_s} \times \dfrac{6ne_1}{bd^2}$ for the given conditions and the value of $\dfrac{f_s}{nf_c}$ corresponding to the maximum allowable unit stresses. Since the value of f_s is known and constant, the only way the value of $\dfrac{f_s}{nf_c}$ opposite $\dfrac{N}{f_s} \dfrac{6ne_1}{bd^2}$ in Table I could be less than that just found would be for f_c to exceed its safe value, indicating that compressive steel is required. In that case the values of k and j are found in Table I opposite $\dfrac{f_s}{nf_c}$, corresponding to the maximum allowable unit stresses. If compressive steel is not needed, the value of k and j are found in Table I opposite $\dfrac{N}{f_s} \times \dfrac{6ne_1}{bd^2}$.

The expression for the area of tensile steel required when the concrete is not overstressed is found by taking moments about a point a distance of $\dfrac{kd}{3}$ from the compressive surface. That is, for bending and direct tension,

$$A_s = \frac{N}{f_s}\left(\frac{e_1}{jd} + 1\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [4]$$

and for bending and direct compression,

$$A_s = \frac{N}{f_s}\left(\frac{e_1}{jd} - 1\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [5]$$

When Equation 5 yields a negative quantity, this will indicate the case of compression over practically the entire cross section.

NUMERICAL EXAMPLES

To show the application of these equations to the case illustrated in Fig. 1, let b equal 14 in.; d, 27 in.; e_1, 33 in.; and N, 30,000 lb in direct compression. Suppose the specifications limit f_c to 650 lb per sq in. and f_s to 16,000 lb per sq in., and give the value of n as 15. These unit stresses lead to a value for $\dfrac{f_s}{nf_c}$ of 1.64.

TABLE I. VALUES OF j, k, AND $\dfrac{f_s}{nf_c}$

$N\left(\frac{6ne_1}{f_s bd^2}\right)$	$\frac{f_s}{nf_c}$	j	k	$N\left(\frac{6ne_1}{f_s bd^2}\right)$	$\frac{f_s}{nf_c}$	j	k
0.0322	9.00	0.967	0.10	1.25	1.00	0.833	0.50
0.0393	8.09	0.963	0.11	1.40	0.923	0.827	0.52
0.0473	7.33	0.960	0.12	1.56	0.852	0.820	0.54
0.0558	6.69	0.957	0.13	1.74	0.786	0.813	0.56
0.0652	6.14	0.953	0.14	1.94	0.724	0.807	0.58
0.0755	5.67	0.950	0.15	2.16	0.667	0.800	0.60
0.0866	5.25	0.947	0.16	2.41	0.613	0.793	0.62
0.0986	4.88	0.943	0.17	2.69	0.563	0.787	0.64
0.1115	4.55	0.940	0.18	3.00	0.515	0.780	0.66
0.125	4.26	0.937	0.19	3.35	0.471	0.773	0.68
0.140	4.00	0.933	0.20	3.76	0.429	0.767	0.70
0.173	3.55	0.927	0.22	4.22	0.389	0.760	0.72
0.209	3.17	0.920	0.24	4.76	0.351	0.753	0.74
0.250	2.85	0.913	0.26	5.39	0.316	0.747	0.76
0.296	2.57	0.907	0.28	6.14	0.282	0.740	0.78
0.347	2.33	0.900	0.30	7.04	0.250	0.733	0.80
				7.56	0.235	0.730	0.81
0.404	2.12	0.893	0.32	8.14	0.220	0.727	0.82
0.466	1.94	0.887	0.34	8.80	0.205	0.723	0.83
0.535	1.78	0.880	0.36	9.53	0.190	0.720	0.84
0.610	1.63	0.873	0.38	10.36	0.176	0.717	0.85
0.694	1.50	0.867	0.40	11.30	0.163	0.713	0.86
0.785	1.38	0.860	0.42	12.40	0.149	0.710	0.87
				13.69	0.136	0.707	0.88
0.885	1.27	0.853	0.44	15.20	0.124	0.703	0.89
0.995	1.17	0.847	0.46	17.0	0.111	0.700	0.90
1.117	1.08	0.840	0.48				

The value of $\dfrac{N}{f_s} \times \dfrac{6ne_1}{bd^2}$ is 0.545 and the value of $\dfrac{f_s}{nf_c}$ opposite in Table I, by interpolation if necessary, is 1.76. Since f_s is held to a value of 16,000 lb per sq in., the value of f_c is shown to be permissible. The value of j is then found as 0.879. Substituting in Equation 5, A_s equals 0.73 sq in.

A balanced design is one that takes full advantage of the allowable unit stresses. In a cross section containing steel in the tensile face only, this condition would occur when the computed value of $\frac{N}{f_s} \times \frac{6ne_1}{bd^2}$ exactly equaled that in Table I opposite the value of $\frac{f_s}{nf_c}$, corresponding to the maximum allowable unit stresses.

When dealing with cross sections requiring compressive steel (Fig. 2), the thrust may be divided into two parts. The first part, N_1, is resisted by the concrete and enough tension steel, A_{s1}, to cause a balanced design. The second part, N_2, is resisted by compressive steel, A'_s, and an additional amount of tension steel, A_{s2}. The first part, N_1, may be found as the proportional part of the total thrust, N, given by the ratio of the value of $\frac{N}{f_s} \times \frac{6ne_1}{bd^2}$ for a balanced design to the computed value of the same quantity for the given conditions. Both k and j are also found opposite the value of $\frac{f_s}{nf_c}$ for a balanced design.

From Equation 4, for bending and direct tension,

$$A_{s1} = \frac{N_1}{f_s}\left(\frac{e_1}{jd} + 1\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [6]$$

From Equation 5, for bending and direct compression,

$$A_{s1} = \frac{N_1}{f_s}\left(\frac{e_1}{jd} - 1\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [7]$$

To determine the additional tensile steel required, take moments about the compressive steel (Fig. 2). Then, for bending and direct tension,

$$A_{s2} = \frac{N_2}{f_s}\left(\frac{e_1}{a} + 1\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [8]$$

And, for bending and direct compression,

$$A_{s2} = \frac{N_2}{f_s}\left(\frac{e_1}{a} - 1\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [9]$$

The compressive steel required is found by equating the algebraic sum of the forces normal to the cross section; that is

$$A'_s = \frac{N_2}{(n-1)f_c} \times \frac{e_1}{a} \times \frac{k}{k - \frac{d'}{d}} \quad . \quad . \quad . \quad . \quad [10]$$

The formula for A'_s is the same whether the thrust is tensile or compressive.

It is of interest that these equations hold good for the special case of pure bending by retaining only the $\frac{e_1}{jd}$ terms in the equations for A_s, A_{s1}, and A_{s2}, and noting that Ne_1 is equal to the bending moment.

To illustrate the case of a cross section requiring compressive reinforcement, let N be 36,000 lb instead of 30,000 lb as in the previous example; also, let d' equal 3 in. Then $\frac{N}{f_s} \times \frac{6ne_1}{bd^2}$ equals 0.654; and correspondingly, $\frac{f_s}{nf_c}$ equals 1.56. The value of $\frac{f_s}{nf_c}$ for a balanced design is 1.64; hence compressive steel must be provided. Values for $\frac{N}{f_s} \times \frac{6ne_1}{bd^2}$ of 0.604; for k, of 0.38; and for j, of 0.873 are taken from Table I opposite $\frac{f_s}{nf_c}$ for a balanced design.

Then $N_1 = \frac{0.604}{0.654} \times 36{,}000 = 33{,}200$ lb; and $N_2 = 36{,}000 - 33{,}200 = 2{,}800$ lb. From Equation 7, $A_{s1} = 0.83$ sq in. From Equation 9, $A_{s2} = 0.07$ sq in. The total tensile steel required is $0.07 + 0.83 = 0.90$ sq in. From Equation 10, $A'_s = 0.60$ sq in.

It is valuable to note that excesses in compressive steel can be remedied by arbitrarily lowering the allowable value of f_s, and excesses in tensile steel can be corrected by lowering the allowable value of f_c. All calculations have been made with a slide rule.

Neutral Axis in a Reinforced Concrete Member Subjected to Combined Stress

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DETERMINATION of the neutral axis in a reinforced concrete member subjected to combined stress, as described by E. Mörsch (*Der Eisenbetonbau*, Vol. 1, 1st half, page 450, 1920) and attributed by him to C. Guidi, is familar to most structural engineers. The method which is an extension of one given by O. Mohr, involves drawing a closing line in a string polygon in such a way as to make two areas in the polygon equal (CIVIL ENGINEERING, February 1933, page 93). This

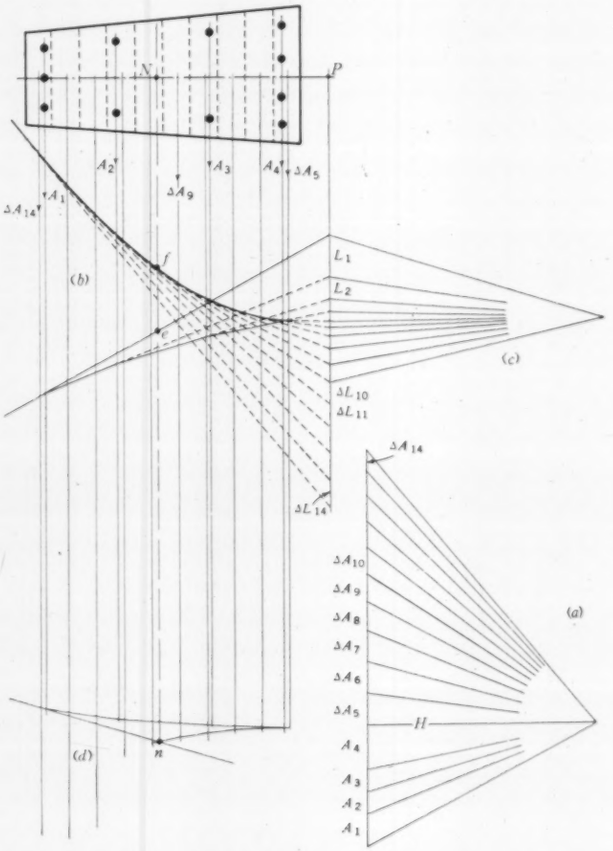

FIG. 1. SOLUTION BY TWO-POLYGON METHOD

procedure is usually inconvenient. It can be avoided by drawing another string polygon, as proposed for plain concrete by N. Raubal (*Beitrag zur Ermittlung der Druckspannungen in Querschnitten unter Ausschluss von Zugspannungen, Österreichische Wochenschrift für den offentlichen Baudienst*, Vol. 19, Heft 16, page 269, April 17, 1913).

Raubal's method is less well known and may be of interest. In the accompanying Fig. 1 let the trapezoid represent the cross section of any loaded prismatic reinforced concrete member with at least one axis of symmetry, and assume that the resultant load on the cross section passes through the point P on this axis. Divide the cross section into strips perpendicular to the axis of symmetry, and denote the transformed cross-sectional areas of the steel—that is, the actual cross-sectional areas times the ratio of modulus of elasticity of steel to that of concrete—by A_1, A_2, A_3, A_4, and the cross-sectional areas of the concrete in the strips by $\Delta A_5, \Delta A_6, \ldots \Delta A_{14}$. Consider all these areas as loads acting perpendicular to the axis of symmetry, and lay them off on a load line, beginning with the transformed steel areas and continuing with the concrete areas subjected to the greatest compressive stress. Draw a force polygon (*a*) for these areas as loads and a corresponding string polygon (*b*), extending the strings to a line through P perpendicular to the axis of symmetry.

Denote the intercept on this line between the first and second steel strings by L_1, the intercept between the second and third strings by L_2, and so on to ΔL_{14} for the intercept between the next to the last and the last concrete string. Considering these intercepts as forces acting along the same lines as $A_1, A_2, \ldots \Delta A_{14}$, respectively, begin drawing the force polygon (*c*) and the corresponding string polygon (*d*), extending the first steel string well across the lines of action of the forces. Then continue to draw the force and string polygons until a concrete string is reached which intersects the first steel string, at n in the figure.

Under the assumption that the concrete does not resist tension, this intersection locates the neutral axis as nN perpendicular to the axis of symmetry of the cross section. (If the force and string polygons were completed and the last string extended to intersect the first, this intersection would determine the neutral axis under the assumption that the concrete does resist tension.) The stress f in the concrete at any distance y from the neutral axis is then given, as Mörsch shows, by

$$f = \frac{P}{Hz} y,$$

in which P is the total load normal to the cross section; H, the polar distance of the first force polygon (*a*); and z equals $\overline{ef}$, the intercept on the neutral axis between the first steel string and the last effective concrete string in the string polygon (*b*).

The proof of the construction just described (suggested by Wilhelm Effenberger, *Zur Bestimmung der Druckspannungen im prismatischen Körper bei Ausschluss der Zugfestigkeit, Zeitschrift des Österreichischen Ingenieur- und Architekten-Vereines*, Heft 19/20, page 1928) makes use of the reciprocal relation between point of application of load and neutral axis. Assuming the same concrete area to be effective in both cases, if the neutral axis for a load at P passes through N, then the neutral axis for a load at N passes through P. It will be observed that the L's and ΔL's are proportional to the products of the areas A and ΔA, respectively, times the distances of the latter from the vertical through P. Consequently they are proportional to the total stresses on the areas A and ΔA, respectively, which would result from a distribution of stress with neutral axis through P. The second string polygon (*d*), then, merely locates the resultant of this distribution of stress, and the reciprocal theorem states that this resultant passes through the neutral axis for a load at P, which is the neutral axis it was desired to obtain.

Our Readers Say—

In Comment on Papers, Society Affairs, and Related Professional Interests

Corrections Noted in Equations for Bulkheads

DEAR SIR: Referring to the article, "Gravity Bulkheads and Cellular Cofferdams," by Raymond P. Pennoyer, in the June issue, I find that the area of the circular segment with a 60-deg central angle (page 304) should be $0.0906r^2$ instead of $0.906r^2$.

On page 200 of the article on "Details of Steel Sheet-Piling Bulkheads" by the same author, in the April issue, the last term of Equation 3 should be $-\frac{4L^2}{w^2(p_p - P_s)^2}$ instead of $\frac{4L^2}{w(P_p - P_s)^2}$.

The equation just preceding his Equation 4 should read

$$\frac{dM}{dd''} = L - (P_p - p_s)\frac{d''^2}{2}; \text{ so that } d'' \text{ will equal } \sqrt{\frac{2L}{P_p - P_s}}.$$

KENNETH L. DEBLOIS, *Assoc. M. Am. Soc. C.E.*

Stockton, Calif.
August 23, 1934

[*Editorial Note: The author has approved these corrections.*]

Significance of Corporate Membership in the Society

TO THE EDITOR: Permit me to call attention to the statement on page 498 of the September number to this effect: "It is significant that Corporate Membership in this body constitutesa qualification for practice in the profession; is generally accepted in lieu of examination by state boards of engineering examiners for license to practice; and by itself usually qualifies an engineer as an expert witness in court actions." This I feel should be corrected in view of the erroneous impression it undoubtedly conveys as to the significance of Corporate Membership in the Society.

In several of the states where engineers' licensing laws are in effect, Corporate Membership does not carry with it a qualification or license to practice professional engineering unless the individual shall have been licensed in the particular state. It is a fact that there are Corporate Members of the Society who are not licensed in New York State or in other states and are, therefore, precluded from the practice of professional engineering in New York State without violation of the law.

It is also my understanding, and I believe that upon inquiry it will be found to be a fact, that Corporate Membership is not generally accepted by the various state boards of engineering

examiners in lieu of examinations as prescribed in their respective statutes. This would be the delegation by an appointed board of a duty devolving upon it without proper authority therefor. In New York State there is a specific requirement relative to the examinations that must be taken. This is mandatory and, as I view the situation, is not subject to modification or waiver on the part of the board.

I also cannot concur in the statement that Corporate Membership in the Society qualifies one to testify as an expert witness in court actions. As a matter of fact, I know of instances where members of the Society who have been in practice for several years have been disqualified as experts. Qualification as an expert in any particular field of engineering goes even farther than the mere licensing by a state board. The licensee may be qualified to testify as to factual matters determined as a result of observation and measurement, but is not qualified to formulate an expert opinion based on such facts or on facts gathered by others, unless he has had particular experience along those lines.

I regret that this above noted misleading statement will come to the attention of so many, especially in view of the vast amount of attention and effort that has been made to advance the status of the profession and to obtain greater respect for it.

ARNOLD G. CHAPMAN, M. Am. Soc. C.E.
President, New York State Society of Professional Engineers

Albany, N.Y.
September 8, 1934

Location of Inflection Points

TO THE EDITOR: The graphical method of locating inflection points (often called fixed points), presented by Otto Gottschalk in the May issue, is based on the assumption that the far ends of the adjoining beams and columns are fixed. A simple graphical determination of the fixed points for other conditions of restraint, or combinations of conditions, may be obtained by assuming spans and columns to be of the same length as Span 2 in Fig. 1, and changing the moment of inertia for each member in such a way as to maintain the same ratio of I/L. Then the moment of inertia will give directly the comparative strength of all members. The assumed conditions to illustrate the method are shown in Fig. 1, in which the length of beams and height of columns equal 12 ft.

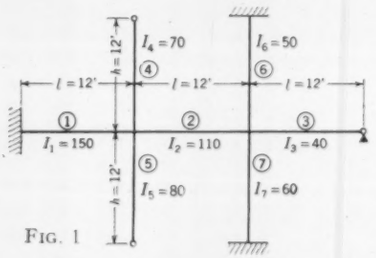

FIG. 1

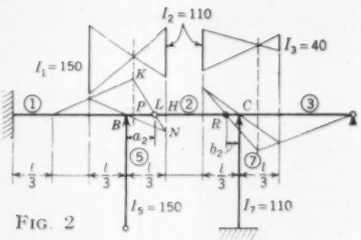

FIG. 2

Now substitute for the frame an equivalent continuous beam over elastic supports (Fig. 2). Then the elastic stiffness of Cols. 5 and 7 will be 150 and 110, respectively, which correspond to the new moments of inertia of these columns. Next draw the third-point lines and reversed third-point lines. Then if the columns at B and C offer no elastic resistance—that is, if the beam is continuous over four supports—the fixed points are obtained as in Fig. 2.

For elastic supports, the left fixed point would be between points L and H. A location at L would indicate no restraint from the column (the case shown in Fig. 2), and a location at H would indicate complete restraint at B by Col. 5. The influence of an elastic support on the location of the fixed point is expressed by a third kind of vertical line, the so-called "elastic line." There are two for each support, one for each reversed third-point distance.

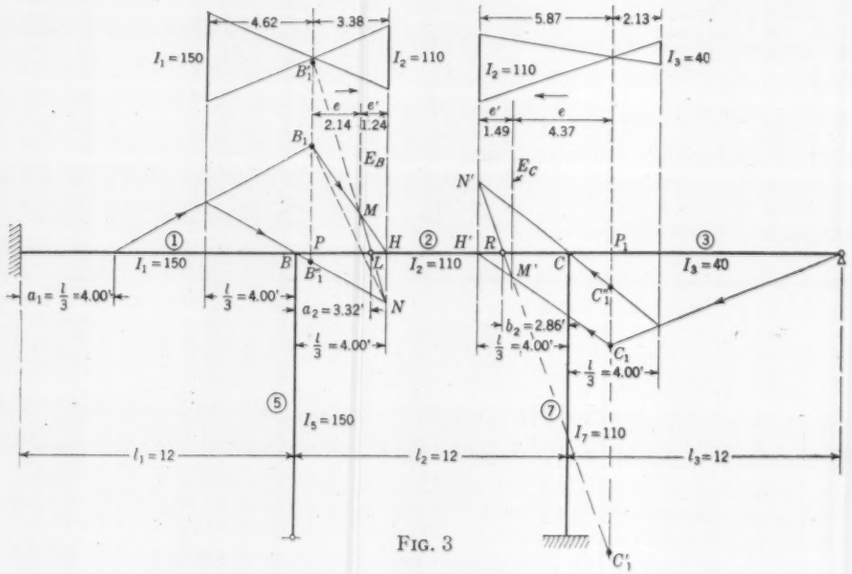

FIG. 3

The elastic line for the right reversed third-point distance at B will divide this distance PH in some ratio, $e:e'$, in Fig. 3, in which

$$\frac{e}{e'} = \frac{3\,I_h}{I_1 + I_2} \text{ (for columns with free base)} \quad [1]$$

$$\frac{e}{e'} = \frac{4\,I_h}{I_1 + I_2} \text{ (for columns with fixed base)} \quad [2]$$

In our example it is found that $\frac{e}{e'} = \frac{3 \times 150}{150 + 110} = 1.73$

Therefore, by computation e equals 2.14 and e' equals 1.24, since PH equals 3.38.

Now the line B_1H is drawn (Fig. 3), and the elastic line locates point M. This point, when connected with N, locates the left fixed point, L. Similarly, the right fixed point distance may be obtained (Fig. 3). It will be noted that if the line NM is extended to B'_1, the scale ratio, $B_1''B_1 : B_1''B_1'$, gives the amount of moment that will pass over the support B from Span 2 to Span 1. The rest of the moment will be taken by Col. 5.

In the famous book by Ritter and Culmann, *Anwendungen der graphischen Statik* (Vol. 3, Zurich, 1900), the location of the elastic line is given as

$$\frac{e}{e'} = \frac{u\,L_1}{2\,E\,I} \quad [3]$$

where u represents the elastic mass. They give for u some rather complicated formulas, which refer to large columns composed of steel trusses for supporting bridges. These formulas when simplified give the following value of u for a single column with a constant moment of inertia, I_h, and a height of h:

$$u = \frac{4\,E\,I_h}{h} \text{ (for column with fixed base)} \quad [4]$$

$$u = \frac{2\,E\,I_h}{h} \text{ (for column with free base)} \quad [5]$$

The span L_1 is supposed to be to the left of the support in question. The only case considered is for a beam with constant moment of inertia. It is my contention that Culmann and Ritter made a mistake in the last expression, in which u really should equal $\frac{3\,E\,I_h}{h}$.

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August 22, 1934

SOCIETY AFFAIRS

Official and Semi-Official

Matters of Etiquette for Writers

Contributions to "Proceedings" Subject to Rational Regulations

FROM TIME to time the Society has published certain rules and suggestions for the guidance of contributors to its publications. The reasons for many of these rules are self-evident and need no explanation, but others, although just as logical, are not so obvious.

In writing material for publication by the Society, authors will naturally bear in mind some fundamental requirements. For example, certain kinds of literature are not acceptable because they are not of interest primarily to civil engineers and because some other publication may prove to be a more effective vehicle for that particular type of writing. As an extreme example, the Society would necessarily reject many articles, however excellent, that would be acceptable to the average popular weekly.

Within such reasonable limitations, the Society attempts to segregate suitable papers into two general classes, those acceptable for CIVIL ENGINEERING and those acceptable for PROCEEDINGS and for final publication in TRANSACTIONS. The ideal paper for PROCEEDINGS is the learned treatise advancing new theories in the design or construction of civil engineering work for the acid test of widespread criticism or discussion. Strictly speaking then, PROCEEDINGS is a forum, a meeting place for formal argumentation in the field of civil engineering.

As in the case of all formal argumentation, participants must abide by certain prescribed regulations, culminating eventually in a series of papers that are eligible for prizes. Interpreting these regulations, the editor is in a sense a referee rather than a "rewrite man," and the rules he enforces are for the most part rules of etiquette as applied to formal argument. It will be valuable to review some of the more important provisions, as laid down by the Committee on Publications.

1. Contributors to PROCEEDINGS are expected to be interested primarily in the dissemination of technical knowledge. Personalities, either extremely laudatory or derogatory, are considered bad taste. Furthermore, they are a waste of space and effort because, unlike current periodicals, the papers are intended for record and for the use of research workers many years in the future. With the passing of time, personalities become only amusing if they remain interesting at all.

2. Occasionally a writer objects to changes in his manuscript of any nature on the ground that such changes may rob the paper of his "personality." The Committee on Publications maintains that it is the duty of every technical writer to secure all necessary criticism and assistance in expressing his thesis precisely and accurately. Editorial changes to this end should be analyzed by an author with the idea of expressing his meaning in words that can be understood by engineers everywhere. In technical argument, language must be considered primarily as a precision instrument comparable with the most important physical devices used by the engineer.

3. It is the duty of the author of a main paper to circumscribe the field covered so that those who read may not apply his arguments indiscriminately and erroneously to a broader field. Then it is the duty of those who criticize the paper to confine their arguments to that paper only and to the limitation of scope adopted by its author. Obviously it is unfair to permit discussion of a phase of the subject which the author considered extraneous and then to expect him to answer the comment in his closure. On the other hand, both care and diplomacy are needed to ensure that the discusser is not restricted beyond a reasonable interpretation of the author's scope. To the editors is assigned the unpleasant duty of interpreting these requirements in fairness to both parties and to that more important group—the readers.

4. In particular, it has been considered unwise to permit discussion on the views of another discusser. If sanctioned, such practice, by successive digressions, would inevitably lead off at a tangent. Instead, fairness to the author demands that the discusser adhere to the subject of the main paper in approval, corroboration, or criticism. In this way all arguments are applicable to the principal thesis, and the author in his closure can summarize or can defend himself as the case requires.

5. It is a common experience to receive a discussion composed entirely of a description of a method supplementary to the original paper. In other words, this discusser would dismiss the original and substitute a method of his own choice without reference to the principal subject under discussion. The etiquette of formal argument does not permit such substitution. This is not to say that a critic of a paper may never introduce new ideas. Such material, however, must be "tied in" to the original paper so as to demonstrate conclusively that it is a relevant argument and that the writer is not merely using the paper as a tenuous excuse for introducing a parallel but essentially extraneous concept—in effect, an independent paper.

6. It is also common practice for a discusser to support his arguments by extensive quotations from standard textbooks or other published material, which the Committee on Publications considers "readily available elsewhere." From the standpoint of etiquette, this practice is unfair to the author of the main paper and may also be unfair to the original author quoted. The Society takes the stand that it is the duty of writers to epitomize quoted material (except perhaps very brief sentences or statements) and to indicate to the reader exactly how the interpreter would apply the quotation to the subject immediately at hand. Then a footnote reference to the original source will be sufficient for the research worker to satisfy himself that the interpretation has been a fair one.

7. Because of the tremendous amount of material that the up-to-date engineer must read, it is considered bad etiquette to burden him with extensive republication of material which he can find in other publications if he chooses to look them up. Some writers, particularly discussers, will often launch upon an extensive review of a method published elsewhere, although perhaps in slightly different form or in a different language. In this case, a footnote reference with a brief introductory statement will usually suffice to support the arguments which it is desired to advance.

8. Insistence on a third-person style is almost entirely a matter of etiquette based on the slogan, "Submerge personalities." A writer cannot divorce himself from his writing. It is enough, however, if he keep himself modestly in the background. By so doing he focuses attention on the technical ideas rather than on the person who expounds them.

9. It is considered bad etiquette for a writer to appear to be "advocating special interests," and yet this is a common fault among writers, mostly unintentional. One form of it is to support arguments by too frequent reference to one's own book, in effect seeming to urge that a reader would do well to acquire that book.

10. Text, tables, and illustrations are methods of expression, and the same information should not be expressed by more than one of these methods. The reasons for including tables or illustrations must be made apparent in the text. The most important part of a paper in PROCEEDINGS is the text material, and the tables, illustrations, and mathematics are supplementary to it. The latter items are offered as exhibits to demonstrate a definite description of importance mentioned in the text. The entire thesis should be stated in the text part of the paper, and the illustrations, tabular matter, and equations should be introduced by number, definitely, and described wherever necessary to bring out the point intended. Tabular matter, illustrations, and equations inserted in the paper

without introduction in the text are automatically deleted by the editor, under instruction from the Committee.

11. In PROCEEDINGS and TRANSACTIONS it is considered best form to use the accepted English language, excluding foreign terms. Latin and Greek phrases are discouraged, and modern foreign words or phrases are barred unless a writer is willing to define such use in English. Slang, colloquial phrases, and technical catch words characteristic of certain parts of the United States are discouraged in deference to readers over the entire world, whose knowledge of English may be limited to words defined in books.

12. Vague expressions, such as "recently" or "a few years ago," are unfair to those who will study TRANSACTIONS in the years to come. The observation may have been made as applying to a year or two before the manuscript was written. Published in PROCEEDINGS perhaps several months after a careful review by experts, the paper is discussed at length and finally published in TRANSACTIONS. The date of the TRANSACTIONS volume, then, is the only clue a reader has as to when "recent" was. The writer in PROCEEDINGS should always give dates.

13. The Committee on Publications does not solicit papers for PROCEEDINGS and TRANSACTIONS; and when papers are submitted the committee reserves the right to reject them for any cause. With this reservation in mind, it is considered not proper for an independent contributor or an individual member of the Society to imply a willingness on the part of the Committee on Publications to print some material in the future. For example, an author should not state that "The Department of . . . is conducting an extensive series of tests in this field, and it is hoped that the results will be made available in the near future."

Suppose that this statement is published in TRANSACTIONS for the permanent record. Subsequently, the tests in prospect might conceivably be abandoned and nothing further published. On the other hand, the tests might be finished some months or years later and the Committee on Publications made to feel obligated to publish them on the strength of the earlier announcement. This explains the aim of the Committee that papers destined for TRANSACTIONS dealing with construction shall describe completed work, completed designs, or some completed phase of the work.

14. An author should not ask questions in his closing discussion, because for the present his is the final word on the subject. If questions need to be answered more fully than has been done in the preceding discussion, they should be settled by personal correspondence before the closing discussion is written.

In connection with most of the foregoing items, there are other rational explanations of editorial policy, based on the necessity for a publisher to be economical in his use of space or on his natural desire to produce a work of the best possible appearance consistent with good economy. Members interested in the detailed requirements for papers in PROCEEDINGS should write to Headquarters for the pamphlet entitled "General Information on Society Publications and Preparation of Manuscript for PROCEEDINGS."

Society Mail

THE CONSTITUTION of the American Society of Civil Engineers provides that "the offices of the Society shall be located in the City of New York," and a similar provision has been included since the earliest draft, adopted in 1852. The Society now has members in every state in the Union, and in many foreign countries as well. A large number of these men never find it convenient to visit the Headquarters in the Engineering Societies Building in New York.

How does the member maintain his contacts with the Society when he lives at a distance from New York? Obviously he must utilize the mails for that purpose and likewise must obtain publications and other communications from the Society through the same medium. As an indication of the extent of this phase of the work of the Secretary's staff some figures and facts may be of interest.

Several times a day the incoming mail is opened, the envelopes being cut by an automatic machine. Each letter is then examined and routed to the department best equipped to answer it. Every day brings requests for copies of publications, changes of title and address, correspondence about papers awaiting publication, checks in payment of dues, and applications for membership. Questions on engineering topics, which require some research outside the publications of the Society, are often received, and these are answered as fully as circumstances permit.

Besides replies to these letters, the volume of outgoing mail is constantly growing. In a recent week, over a thousand pieces of first-class mail and more than a hundred parcel post packages were sent out. This did not include bulk mail, such as publications, notices of dues, and ballots for officers. Twice each month, in advance of the publication dates of PROCEEDINGS and of CIVIL ENGINEERING, the mailing department runs off on the addressograph machine enough envelopes to send these publications to every member entitled to them. For each issue the envelopes are then sorted in accordance with Post Office requirements into more than fifty groups, after which they are shipped to the printer handling that publication, who inserts the copies and puts them in the mail. The weight of a single month's issue of PROCEEDINGS amounts to three tons, and CIVIL ENGINEERING adds three and a half tons more.

Several times a year there is a bulk mailing of printed or mimeographed matter to all members, and in such cases the addressing and inserting of material into the envelopes are both taken care of by the office staff.

Except for special letters and packages, the method of applying stamps by the old process of "licking and sticking" has long since been abandoned in favor of a postage meter through which the envelopes are passed at a maximum rate of 5,000 an hour. For this machine, the Society buys from the New York Post Office a thousand or more "impressions" at one time, of either the two-cent or three-cent denomination, and the meter is set ahead each time to indicate the number of impressions for which payment has been made in advance.

For bulk mailing of publications, ballots, and such matter, an addressograph machine is used. Into it are fed from one side, one at a time, the metal address plates at the rate of 3,300 plates an hour, to meet at some point in the interior of the machine the stream of blank envelopes which arrives from the opposite side. The tasks of cutting the address stencils and of keeping them up to date and filed in proper order, for use as need arises, require the constant attention of several of the staff.

In the general office at Headquarters the staccato hammer of typewriters joins with the clicking of the teletype telegraph connection and the heavier roll of the addressograph and stamping machines to indicate that there is a never-ending flow of mail to and from the 14,750 members of the Society scattered all over the world.

Ninety-Nine Volumes of Technical Literature

ON NOVEMBER 5, 1852, at the office of the late Alfred W. Craven, M. Am. Soc. C.E., Chief Engineer of the Croton Aqueduct Department, 12 civil engineers and architects met for the first time with the avowed purpose of organizing a professional society. The immediate outcome of this meeting was a letter broadcast among a select group of engineers and architects, inviting them to become charter members. This letter listed the proposed activities of the Society as "periodical meetings for the reading of professional papers, and the discussion of scientific subjects, the foundation of a library, the collection of maps, drawings, and models, and the publication of such parts of the proceedings as may be deemed expedient."

The first professional discussion before the Society was on the subject of "The Relief of Broadway," in which James Laurie, then President of the Society, took part. There were eight members in attendance. In 1872, a series of 32 professional papers were gathered together, bound, and issued to the membership as Volume 1 of TRANSACTIONS. The Society at this time numbered a total of 337 members. In this same year, the late George A. Norman, M. Am. Soc. C.E., established a fund for the Norman Medal, to be awarded annually for a paper "judged worthy of special commendation for its merit as a contribution to engineering science." In 1874, this medal was first awarded to J. James R. Croes for his paper in Volume 3, entitled "Memoir of the Construction of a Masonry Dam." The paper by Harrison P. Eddy, President Am. Soc. C.E., in Volume No. 99 of this series, is the 1,890th of these technical treatises written by a long and illustrious list of technical men. To these 1,890 papers may be added the 96 special papers presented at the International Engineering Con-

gress under the auspices of the Society in St. Louis, Mo., in October 1904, making a total of 1,986 formal papers presented for analytical criticism in the great forum of the Society extending over a period of more than eighty years. The papers from the International Engineering Congress appear as six supplementary parts of Volume 54, thus making the TRANSACTIONS library to date total 105 separate books.

Volume 99, which is about to be distributed to the present membership, contains 35 papers, among which may be found a number of subjects of fundamental interest and value to every member of the Society. Papers describing the construction of engineering projects and studious theoretical papers on the design of structures in general are about equally divided, and these two subjects naturally head the list. Papers of interest to members of the Irrigation Division and Power Division are next in order, and in addition there are representative papers in the fields of city planning, highways, sanitary engineering, and surveying and mapping. Forty-three authors of main papers are represented, with 267 discussions of them. Memoirs of deceased members, 102 in number, form a most valuable part of this volume.

Each member in good standing should receive his copy of Volume 99 of TRANSACTIONS during October. Those receiving the paper-bound issues may look for their copies in conjunction with the current October PROCEEDINGS, and entitled *Proceedings Part 2, Transactions Number 1934*. This arrangement effects considerable economy in mailing cost.

Copies in cloth or half morocco are not eligible for the same preferred mailing rates. They will therefore be sent out independently of PROCEEDINGS. According to the established schedule, these bound volumes are expected to be posted before the end of October.

Credit Where Credit Is Due

AN INGENIOUS device—a combination of the centrifuge and the photo-elastic cell—is being used at Columbia University to determine stresses in retaining walls, tunnel linings, and other engineering structures, caused by the pressure of the supported earth. The apparatus, briefly mentioned in the September issue of CIVIL ENGINEERING, page 496, is being developed and the test conducted by Prof. Philip B. Bucky, of the School of Mines. Due to an editorial slip, this work, one of the activities of the Society's Committee on Earths and Foundations, was credited erroneously in the September number to C. P. Berkey, M. Am. Soc. C.E. It is anticipated that in the near future an article by Professor Bucky on the results of his work will be available for publication by the Society.

Student Prizes Awarded

DURING the 1934 commencement season many of the Local Sections of the Society followed their usual custom of presenting awards to engineering students graduating with high scholastic distinction from colleges and universities within their territories. When his application has been approved by the Board of Direction, the recipient of such an award is permitted to join the Society as a Junior, and the Local Section pays his initiation fee and dues for the first year. So far the following prize winners for 1934 have been reported to Society Headquarters:

NAME OF STUDENT	COLLEGE	LOCAL SECTION GIVING AWARD
Frank Mark Clinton	University of Arizona	Arizona
Melvin A. Dobbs Edgar John Jacob Luetzelschwab	University of Illinois	Central Illinois
Edward MacNeil Johnson	University of Cincinnati	Cincinnati
Paul Haskins Owen, Jr.	Case School of Applied Science	Cleveland
Marian Eugenia Barnes	University of Colorado	Colorado
Ludlow Vanderburg Clark Deichler	Georgia School of Technology	Georgia
Harold Chester Crumpacker	Northwestern University	Illinois
John Harrington Keller	Rose Polytechnic Institute	
Joseph Joslyn Rimsay	Lewis Institute of Technology	
John Edward Schreiner	Armour Institute of Technology	
John Safford Wiley	Purdue University	
Eugene Louis Wittenborn	University of Illinois	
Robert Horace Brown	Iowa State College	Iowa
John Floyd Schell	State University of Iowa	
Fred Joseph Maynard	Cornell University	Ithaca
Donald George Gentry	Kansas State College	Kansas State
Charles Eugene Spahr	University of Kansas	
Alfred Joseph Cooper, Jr.	Tulane University	Louisiana
Carey Allen Randall	Louisiana State University	
Hugh Gordon Conley	University of Southern California	Los Angeles
George Henry Pickett	California Institute of Technology	
David Kosh	Columbia University	Metropolitan
Garland Lee Gray	New Mexico State College	New Mexico
John Macbeth Bird	Duke University	North Carolina
Frederick Eugene Culvern	University of North Carolina	
William New	North Carolina State College	
Miles Stokes Kersten John Frederick Ripken	University of Minnesota	Northwestern
T. A. Halbrook	Oklahoma Agricultural and Mechanical College	Oklahoma
Thomas Field Thompson	University of Oklahoma	
John Raphael Dietz Frederick Ernest Graef, Jr. Robert William Thompson, Jr.	Drexel Institute	Philadelphia
John Philip Hiltz, Jr.	Carnegie Institute of Technology	Pittsburgh
Harold Arthur Schaill	University of Pittsburgh	
Arnold Ziegler Greenlaw	Oregon State Agricultural College	Portland (Ore.)
David Junior Peery	Missouri School of Mines	St. Louis
William Braund Lambert Robert Blemker Brooks, Jr.	Washington University	
Kenneth Fraine Vernon	University of California	San Francisco
Harry Leonard Hesselmeyer	Stanford University	
Kenneth John Nollie	University of Idaho	Spokane
William Thomas Rice	Virginia Polytechnic Institute	Virginia
G. A. Royce	Virginia Military Institute	
James Arthur Grady, Jr.	University of Virginia	

Another award of Junior membership made at commencement time was that of the Frederick B. Robinson Prize to Roland Robert Small, of the College of the City of New York.

Society Appointees

HARRISON P. EDDY, President Am. Soc. C.E., has been appointed a Society representative on the John Fritz Medal Board of Award.

J. P. H. PERRY, M. Am. Soc. C.E., has accepted an appointment to represent the Society on the Engineers' Council for Professional Development.

HOWARD K. PRESTON, M. Am. Soc. C.E., represented the Society at the centenary celebration of the University of Delaware, held at Newark, Del., May 11–13, 1934.

J. C. STEVENS, C. E. BEARDSLEY, and E. W. LANE, Members Am. Soc. C.E., and L. G. STRAUB, H. D. VOGEL, and CHILTON A. WRIGHT, Associate Members Am. Soc. C.E., have been appointed members of the Society's Committee on Hydraulic Research.

GEORGE E. STREHAN, Assoc. M. Am. Soc. C.E., represented the Society at a conference on the building code, called by the American Standards Association in New York, N.Y., on July 10, 1934.

Preview of Proceedings

Four main papers will appear in the October issue of PROCEEDINGS *in addition to the usual discussions. From one, engineers interested in the silt problem will be able to secure data on the life of reservoirs; in another, those concerned with statistical analysis will find a new method of applying the probability function; in the third, students of rainfall and run-off will note a method for determining the relation between these two elements, based on frequency diagrams; and in the fourth, structural engineers will find a theory of analysis for continuous structures by traversing the elastic curve of deflected members.*

The Silt Problem

AMERICA'S IRRIGATION institutions depend so intimately on the storage of water, and the life of storage reservoirs depends so definitely on the flow of sediments into them, that this problem of silt, like the sword of Damocles, hangs over us, a threat and a challenge. This is the theme of J. C. Stevens, M. Am. Soc. C.E., in his paper, "The Silt Problem," also scheduled for the October PROCEEDINGS.

Empires with teeming populations have grown up below such reservoirs as Elephant Butte on the Rio Grande, Roosevelt on the Salt River, McMillan on the Pecos, and Boulder on the Colorado. Each one is slowly but certainly being deprived of its ability to receive and deliver the water so vital to the continued existence of those empires. According to Mr. Stevens, in three generations the people below Elephant Butte will have to seek other means of storage. In five generations Boulder Reservoir, not yet in service, will be unable to supply the water necessary to the existence of the institutions dependent upon it. Yet on this reservoir alone will hang the security of the entire Imperial Valley against flood menace, the irrigation of millions of acres, the domestic water supply of half of California's people, and power service to seven states.

Unless effective steps are taken to preserve the integrity of storage facilities, those areas now vibrant with life must eventually become deserts again. New reservoirs can be built; the present dams can be raised. But Mr. Stevens states that ultimately, within some definite number of generations, all such measures will prove futile and these empires must fade from the picture.

The great natural forces of wind, rain, frost, and floods are the real sources of erosion and silt. They buffet man unmercifully and mock his best endeavors. Yet so conceited is he that he likes to think his is the mighty hand. So we have forestry, flood control, and erosion control, interlaced with billions of dollars of appropriations and great significance in politics. Actually man can accomplish relatively little, but to whatever extent he can ameliorate the difficulty, the problem is a challenge to his mightiest efforts and worthy of his greatest achievements.

In this paper, Mr. Stevens sets forth the problem of silt in all its phases with a mass of authentic data. The records of silting of some 33 reservoirs and the suspended silt carried by 172 rivers of the world are presented. Sedimentation processes; the life of reservoirs; space occupied by silt; stream transportation of silt; its control and origin, are all treated in this paper. The record manuscript, containing over 100 pages, is on file in the Engineering Societies Library in New York. A summary of the paper was presented by Mr. Stevens at a joint meeting of the Irrigation and Power Divisions of the Society at its Annual Convention in Vancouver, B.C., on July 12, 1934.

An Asymmetric Probability Function

VERY OFTEN in engineering, problems that require statistical analysis are supported by data so meager that the use of elaborate analytical methods is scarcely justifiable. The classical work of Karl Pearson and the Danish statisticians forms a background of the science by which, heretofore, most engineering data have been analyzed. Unfortunately, where the probability function is other than that of the normal curve, the determination of the constants involved generally becomes a difficult task. Furthermore, according to J. J. Slade, Jun. Am. Soc. C.E., the final results will seldom have meaning unless the data are very complete. In his paper, "An Asymmetric Probability Function," scheduled for the October PROCEEDINGS, Mr. Slade introduces a function that differs as little as possible from the normal in its general characteristics. Nevertheless, it allows an unlimited degree of skewness. It is claimed to be an easy curve to apply and one for the application of which existing standard tables may be used. The paper is divided into three parts, of which Section 1 is a critical discussion of the various methods now in use to analyze frequency distribution. In the second section, Mr. Slade discusses the requirements of a function that is to be one degree more general than the Gaussian function, and in Section 3 the formulas derived in Section 2 are collected and a procedure is outlined for their use. These are supported by two practical examples.

Relation Between Rainfall and Run-Off from Small Urban Areas

OBSERVATIONS MADE on three selected areas in St. Louis, Mo., are the subject of the major part of the paper, "Relation between Rainfall and Run-Off from Small Urban Areas," by W. W. Horner, M. Am. Soc. C.E., and F. L. Flynt, Assoc. M. Am. Soc. C.E. The records on which the study is based include measurements of rainfall and storm flow for practically all heavy rains that occurred in the period 1914–1933. The ratio of run-off to rainfall, defined in several ways, is shown to vary over a wide range. Rainfall rates at each of the locations studied are reduced and developed into frequency diagrams, and these three rainfall studies, with one other, are combined into a master frequency study for the general region. Run-off is also studied as an independent phenomenon, and the run-off frequency curves are developed. Suggestions are offered as to how the values determined for specific blocks in St. Louis might be modified further so that they could be applied to other types of areas.

It is virtually impossible to confine a study of this scope within a reasonable limit of space in PROCEEDINGS and at the same time include all the supporting data. Enough of the data have been introduced, however, with selected curves, to serve as examples and to support definite arguments introduced for discussion. Studies of the run-off factor are made by means of the unit graph method in the form of three ratios. The accompanying photograph conveys some idea of the nature of one of the areas studied in the paper. Nearly all the pervious part of this is well covered with turf. On one of the other areas, the pervious part consists of small front lawns with some good turf and some bare soil; and, in the third area studied in the St. Louis experiment, the pervious part consists for the most part of some small separated plots of rather hard, packed soil.

ONE OF THE SMALL URBAN AREAS STUDIED BY MESSRS. HORNER AND FLYNT AND DISCUSSED IN THEIR PAPER

Finally, data and studies of a similar set of observations made at Dallas, Tex., indicate how the St. Louis information could be modified to find a probable run-off from similar blocks in Dallas for given intensities and duration periods. The authors are

careful to call attention to the inadequacy of the results secured, declaring their belief that much of importance still lies buried in the available data. The paper is offered in the hope that a wider study and the application of other minds may bring in a more constructive interpretation.

ANALYSIS OF CONTINUOUS STRUCTURES BY TRAVERSING THE ELASTIC CURVE

ANOTHER paper scheduled for the October number of PROCEEDINGS is entitled "Analysis of Continuous Structures by Traversing the Elastic Curve." In it Ralph W. Stewart, M. Am. Soc. C.E., expounds a theory based on an analysis of the elastic curve of a deflected structural member by methods used in surveying. The principles outlined enable a designed to analyze the moments in the members of a continuous frame by a geometrical solution of the alignment of their elastic curve.

For this method Mr. Stewart claims the advantage that it avoids the necessity of memorizing or copying slope deflection equations, and that a series of rules to determine signs of moments, notations, and deflections is not necessary. The paper is refreshingly brief and yet so complete in every detail that the most inexperienced student of structures will have little difficulty in following it step by step. The author offers this system of analysis (which he terms the "traverse method") as a substitute for the theorem of three moments. It furnishes a quick and easy solution of all the moments and all the slopes of the elastic curves over the support.

The forthcoming paper constitutes a more advanced treatment of Mr. Stewart's brief and introductory exposition of the method published in CIVIL ENGINEERING for February 1934. Inasmuch as the previous paper enunciated the basic principles, a student would do well to review it before proceeding with the more advanced supplement.

Tennessee Valley Section Active

A NEW Section of the Society has been formed for the convenience of the large group of members connected with the work of the Tennessee Valley Authority. It is not exactly a new Section; rather it is an enlargement of a former Section. In July, the Board of Direction approved an amendment to the constitution of the Chattanooga Section, establishing branches in Knoxville and Chattanooga, Tenn., and proposing branches at Florence, Ala., and Asheville, N.C. In this respect it is similar to the Texas Section, which has branches in Fort Worth and Dallas. An innovation, however, is the plan to elect one vice-president from each of the branches.

A three-day joint meeting of the Tennessee Valley Section and the Mid-South Section is scheduled to be held at the Hotel Andrew Johnson in Knoxville from November 8 to 10. In addition to the business meetings of both these Sections, a technical program and inspection trips are planned for this period. The program will deal largely with the development of the Tennessee Valley. Both Arthur E. Morgan, M. Am. Soc. C.E., chairman of the Tennessee Valley Authority, and David E. Lilienthal, director in charge of power, have accepted invitations to speak on the plans for and the present progress of the development in the Tennessee Valley. As a feature of the second day of the meeting, Friday, November 9, a trip by auto to the Government's newly made town of Norris is planned. Here lunch is to be served in the Recreation Building, after which the party will inspect the model town, the construction of Norris Dam, and the heavy duty highway over which materials and equipment are being hauled for the undertaking. At an informal banquet Friday evening the new president of the Tennessee Valley Section, still to be elected, will preside. Among the speakers will be President Eddy of the Society.

On Saturday morning three inspection trips are scheduled, to include the aluminum mills at Alcoa, hydro-electro plants on the Little Tennessee River, and the million-dollar highway reconstruction through Newfound Gap. Saturday afternoon is open for attendance at the football game between the University of Tennessee and Mississippi State College.

All members of the Society will be cordially welcomed and a special invitation is extended to nearby Local Sections—Alabama, Georgia, Nashville, North Carolina, and Virginia.

Lantern Lectures Again Available

IN the school year 1933–1934, many of the Student Chapters made good use of the Society's lantern lectures which are loaned without cost to schools and colleges all over the country. This year, 12 of the original 13 titles will still be available, and a letter with suggestions as to their use is being sent to the secretaries of all Student Chapters. The list given below shows the subjects included, and the number of times each set of slides was shown during the past school year.

Carquinez Strait Bridge	16
Cascade Tunnel	14
Catskill Water Supply	15
Conowingo Hydro-Electric Development	10
Coolidge Dam	19
Florianopolis Bridge	17
Hetch Hetchy Water Supply and Power Plant	12
Holland Tunnel	17
Miami Flood Control	16
Mississippi River Flood Control	20
Muscle Shoals Hydro-Electric Development	18
Recent Power Developments at Niagara Falls	14
Westchester County Park System	14

Groups other than Student Chapters may borrow these lectures if they are not already reserved.

News of Local Sections

COLORADO SECTION

On August 13 George T. Seabury, Secretary of the Society, visited the Colorado Section. He was a luncheon guest of the Juniors of the Section, and in the evening a dinner was given in his honor at the Lakewood Country Club near Denver. There were 62 present at this function. After dinner Mr. Seabury gave a talk on the many issues that have held the attention of the Society and engineering groups generally throughout the past two years. Officers for the Colorado Section for the coming year have been elected as follows: R. J. Tipton, President; F. C. Carstarphen, Vice-President; and E. B. Debler, Secretary-Treasurer.

GEORGIA SECTION

Juniors of the Georgia Section were hosts to the other members of the Section at a luncheon meeting held on September 10 at the Robert Fulton Hotel in Atlanta. Several business matters were discussed at this session. Members and guests then had the pleasure of hearing T. T. Flagler, Project Manager for the Techwood Housing Project, who spoke on housing conditions in various parts of the country, with special emphasis on the situation in Atlanta. In presenting statistics Mr. Flagler quoted from U. S. Federal Survey reports.

SAN FRANCISCO SECTION

A special dinner meeting of the San Francisco Section was held at the Engineers Club on July 23 in honor of Harrison P. Eddy and George T. Seabury, respectively President and Secretary of the Society. Both guests of honor spoke on Society affairs of current interest and importance. There were 85 in attendance at this meeting. On August 21 a regular meeting of the Section was held at the Engineers Club, with 123 members and guests present. During the business session several committee reports were read. The feature of the evening was a talk by Wallace B. Boggs, District Engineer of Joint Highway District No. 13, who discussed the topic, "The Broadway Low-Level Tunnel."

Student Chapter News

ALABAMA POLYTECHNIC INSTITUTE

Illustrated lectures furnished by the Society formed an important feature of several of the programs enjoyed by the Alabama Polytechnic Institute Student Chapter during the school year 1933–

1934. Other meetings were addressed by student speakers and by members of the faculty. At the meeting held on October 2, 1933, an interesting talk was given by Howard H. Houk, Bridge Engineer for the Alabama State Highway Department.

ANTIOCH COLLEGE

Students, members of the faculty, and outside speakers cooperated to make the 1933–1934 meetings of the Antioch College Student Chapter interesting and varied. Among the speakers at the eleven sessions were Richard R. Kennedy, associate metallurgist at Wright Field, Dayton, Ohio, and John F. Hale, city engineer of Dayton.

BUCKNELL UNIVERSITY

Several interesting meetings were held by the Bucknell University Student Chapter during the past school year. The entertainment on these occasions consisted of the presentation of papers by students or outside speakers and the showing of illustrated Society lectures. On April 4, 1934, an inspection trip was made to Milton, Pa., where several steel manufacturing and fabricating plants were visited. On April 18 the members of the Chapter attended a meeting of the Philadelphia Section of the Society.

CALIFORNIA INSTITUTE OF TECHNOLOGY

The annual report of the California Institute of Technology Student Chapter for the school year 1933–1934 states that eight meetings, with a total attendance of 529, were enjoyed. The Chapter was host to the Los Angeles Section of the Society at a dinner given at the institute on May 9, 1934. During the year inspection trips were made to several points of engineering interest, including Boulder Dam, the Los Angeles Harbor, and Morris Dam. These were well attended and proved of great interest to the students.

CARNEGIE INSTITUTE OF TECHNOLOGY

The past school year has been an active one for the Carnegie Institute of Technology Student Chapter. The papers presented by students at the various meetings proved interesting and were well received. Among the outside speakers heard on such occasions were J. W. Rickey, Chief Hydraulic Engineer for the Aluminum Company of America; F. S. Merrill, Assistant Division Engineer for the American Bridge Company; and G. S. Richardson, Bridge Design Engineer on the Allegheny County Planning Commission. In all, 31 meetings were held, with a total attendance of 1,726.

CASE SCHOOL OF APPLIED SCIENCE

During the school year of 1933–1934, members of the Case School of Applied Science Student Chapter were privileged to hear several outside speakers. These included R. C. Karl, an artist, who gave an interesting exhibition of sketching; Howard Whipple Green, secretary of the Cleveland Health Council; R. W. Stuck, who described his recent engineering experiences in Russia; and L. K. Whitcomb, Jr, Structural Engineer of the Carnegie and Illinois Steel Company. On January 10, 1934, the members of the Chapter were guests of the Cleveland Section of the Society at their annual dinner meeting. The principal speaker on this occasion was Alonzo J. Hammond, Past-President of the Society.

CATHOLIC UNIVERSITY OF AMERICA

The Catholic University of America Student Chapter reports that there was 100 per cent attendance at its twelve meetings held during the past school year. Students presented papers at most of these sessions, although several outside speakers were also enjoyed. Included among these were F. G. Williams, of the Gurley Instrument Company, who described engineering instruments, and William J. O'Donnell, a member of the staff of the university, who discussed the subject of wind stresses.

CLARKSON COLLEGE OF TECHNOLOGY

During the past school year the Clarkson College of Technology Student Chapter made an inspection trip to Ottawa, Canada, for the purpose of examining the water filtration plant, one of the most elaborate in the East. The Chapter also held several technical sessions, which were addressed by faculty members and outside speakers. Among the latter were C. C. Coleman, city engineer of Potsdam, N.Y., who described the Potsdam filtration plant, and J. P. Burns, of Burns Brothers, and Haley, of Watertown, N.Y., who discussed the St. Lawrence Waterway project.

CLEMSON COLLEGE

Faculty members and students cooperated to make the 1933–1934 meetings of the Clemson College Student Chapter instructive and stimulating. Two outside speakers were also heard on subjects of current engineering interest, and illustrated lectures furnished by the Society were shown on several occasions. On April 11 an inspection trip was made to Spartanburg, S.C., where the water works and sewage treatment plants were visited. Another enjoyable occasion was the annual banquet of the Chapter, which was given on April 18.

COLLEGE OF THE CITY OF NEW YORK

During the school year 1933–1934, the College of the City of New York Student Chapter engaged in numerous interesting activities. The list of outside speakers appearing at the meetings included A. G. Hayden, Designing Engineer of the Westchester County Park Commission; H. T. Immerman, Chief Engineer for Spencer, White and Prentis, Inc., of New York, N.Y.; and Lieut. R. L. Phau, of the U.S. Coast and Geodetic Survey. Several inspection trips were made during the year, and numerous social functions were enjoyed. These included a dance, several banquets, and various athletic events.

COLUMBIA UNIVERSITY

Papers prepared by students were presented at the meetings of the Columbia University Student Chapter held during the past year. These proved of considerable interest and often stimulated heated discussion from the floor. On April 13, 1934, the Chapter gave an informal party, which was distinguished by the presence of several members of the faculty. On April 20 the Chapter acted in the capacity of host at the spring meeting of the Metropolitan Conference of Student Chapters of the Society.

COOPER UNION

Monthly meetings held by the Cooper Union Student Chapter during the past year attracted a total attendance of 350. Among the outside speakers who appeared before these sessions were William H. Meyers, of the Fairchild Aerial Surveys, Inc.; Harry R. Bouton, Division Engineer of the Department of Water Supply of the City of New York; and William Grove, of the firm of Robinson and Steinman, consulting engineers of New York, N.Y. In the spring an inspection trip was made to the screenage plant of the New York City sewerage system. The final meeting of the year took the form of an engineers' banquet.

CORNELL UNIVERSITY

The Cornell University Student Chapter held five meetings during the past school year and participated in three of the sessions of the Ithaca Section of the Society. The programs on these occasions consisted of talks given by students, members of the faculty, and outside speakers. Several motion picture films on subjects of current engineering interest were also shown. One of the most interesting activities of the year was the revival, after half a decade, of the annual civil engineering banquet. This function, which was held on April 19, 1934, was attended by engineering students from the university as well as by members of the Chapter and of the Ithaca Section.

CUSTIS LEE ENGINEERING SOCIETY (WASHINGTON AND LEE UNIVERSITY)

The 1933–1934 meetings of the Custis Lee Engineering Society (Washington and Lee University) Student Chapter were devoted largely to the presentation of student papers. Motion pictures were also enjoyed through the courtesy of the Westinghouse Electric Company, and illustrated Society lectures were presented at several of the meetings. The final session of the school year took the form of a banquet.

DREXEL INSTITUTE

The Drexel Institute Student Chapter was fortunate in being able to have a number of interesting speakers for its 1933–1934 meetings. These included G. R. Young, Major, Corps of Engineers, U. S. Army; Henry J. Sherman, Director of the Society and consulting engineer for the New Jersey Board of Commerce and Navigation; Charles H. Stevens, Chief Engineer of the Philadelphia Department of City Transit; Willard T. Chevalier, publishing director of the McGraw-Hill Publishing Company; and Allen P. Richmond, Jr., assistant to the Secretary of the Society. On May 16, 1934, the Chapter sponsored a dance.

DUKE UNIVERSITY

Illustrated lectures supplied by the Society were shown at several of the meetings of the Duke University Student Chapter during the recently completed school year. A number of stimulating papers were also given by the students. Special activities included an engineering show, held on April 26 and 27, 1934, which was arranged by the Chapter and by student branches of the other engineering societies at the university. This display was viewed by approximately 1,000. Inspection trips were made during the year to the sewage disposal plants in the region.

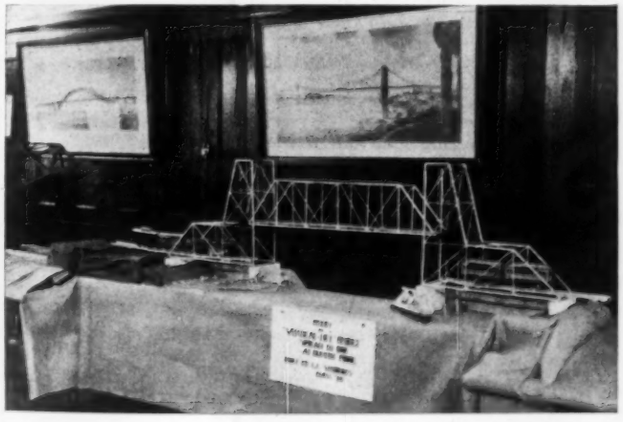
GEORGE WASHINGTON UNIVERSITY

An engineers' open house, sponsored by delegates from the George Washington University Student Chapter and from the other engineering societies at the university, was one of the most successful of the activities of the Chapter during the past school year. Those who attended this event, which was held on November 28, 1933, had the privilege of hearing George O. Sanford, of the U. S. Bureau of Reclamation, who spoke on Boulder Dam.

Other stimulating speakers heard during the year were Clifford Whyte, Engineer of Bridges for the District of Columbia, and George B. Pillsbury, Brigadier-General, Corps of Engineers, U. S. Army.

GEORGIA SCHOOL OF TECHNOLOGY (CIVIL CREW)

The annual report of the Georgia School of Technology (Civil Crew) Student Chapter for the past school year indicates that several interesting meetings were enjoyed. The programs for these occasions consisted of talks given by faculty members and outside speakers. Among the latter were Frederick H. McDonald, Director of the Society and consulting engineer of Atlanta, and Jerry Reade, engineer for the Atlanta district of the Portland Cement Company.



MODEL OF VERTICAL LIFT BRIDGE MADE BY CIVIL ENGINEERING STUDENTS AT IOWA STATE COLLEGE

IOWA STATE COLLEGE

The school year 1933–1934 proved to be an unusually successful one for the Iowa State College Student Chapter. The twelve regular meetings attracted a total attendance of 1,000, and numerous timely engineering topics were discussed at these sessions. Among the outside activities sponsored by the Chapter during the year was the arrangement of the civil engineering program for "Veishea," a three-day exposition held each spring to advertise the college and show the work of all the departments. For this exhibition the Chapter constructed models of various engineering structures. During the year a personnel committee made up of members of the Chapter was in entire charge of senior seminar work.

JOHNS HOPKINS UNIVERSITY

During the past year members of the Johns Hopkins University Student Chapter and the faculty of the university presented helpful papers on a wide range of engineering subjects. On May 17 a joint meeting of the Chapter and of the Maryland Section of the Society was held at the Engineers Club in Baltimore. Another special occasion was an engineers dance, given on May 5 under the auspices of the Chapter and the local student branch of the American Institute of Electrical Engineers.

KANSAS STATE COLLEGE

There was a total attendance of 815 at the 14 meetings of the Kansas State College Student Chapter held during the school year 1933–1934. At some of these sessions motion picture films on subjects of current engineering interest were shown. Other meetings were devoted to the presentation of papers by members of the Chapter and of the college faculty.

LEHIGH UNIVERSITY

Several inspection trips made by the Lehigh University Student Chapter during the past year added to the interest of the engineering work. Among the points of interest visited were the plant of the McClintic-Marshall Corporation at Pottstown, Pa.; the Newark Airport; and many engineering projects in New York City. The list of outside speakers who addressed the regular meetings included Malcolm Taylor, chief inspector for the McClintic-Marshall Corporation; Lyle A. Whitsit, Hydraulic Engineer for United Engineers and Constructors, Inc.; William Bowie, chief of the Division of Geodesy of the U. S. Coast and Geodetic Survey; and Carlton S. Proctor, consulting engineer, of New York, N.Y.

LEWIS INSTITUTE

Varied activities were undertaken by the Lewis Institute Student Chapter during the school year 1933–1934. In addition to meetings at which illustrated lectures furnished by the Society were enjoyed, there were sessions addressed by outside speakers. These included Loran D. Gayton, Assistant City Engineer of Chicago; H. Barker, of the Portland Cement Association; and Melvin L. Enger, recently elected dean of the College of Engineering of the University of Illinois. Frequent inspection trips were made during the year to points of interest in Chicago, including the Chicago Avenue water tunnel, the laboratory of the Portland Cement Association, and the Chicago Lighting Institute.

CIVIL ENGINEERING FLOAT IN THE IOWA STATE COLLEGE SPRING EXPOSITION

LOUISIANA STATE UNIVERSITY

Among the activities of the Louisiana State University Student Chapter during the school year 1933–1934 was the sponsoring of the annual "Engineering Day." The entertainment at the regular meetings consisted chiefly of the presentation of illustrated lectures furnished by the Society, although a few papers by students were also enjoyed on some of these occasions.

MANHATTAN COLLEGE

Outside speakers addressed most of the meetings of the Manhattan College Student Chapter held during the past year. Included on the list of such speakers were Ole Singstad, Chief Consulting Engineer on Tunnels for the Port of New York Authority; Frederick H. Frankland, Director of the Engineering Service of the American Institute of Steel Construction; William G. Grove, of the firm of Robinson and Steinman, of New York, N.Y.; and William Mullee, of the American Hard Rubber Company. The Chapter participated in several joint meetings of all the Student Chapters in the Metropolitan district.

MARQUETTE UNIVERSITY

Varied programs of entertainment marked the 1933–1934 meetings of the Marquette University Student Chapter. An engineers' picnic was one of the diversions of the late spring, and several dinners were given during the year. At some of the technical meetings illustrated lectures supplied by the Society were shown. Other sessions were addressed by outside speakers and members of the faculty.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The 1933–1934 activities of the Massachusetts Institute of Technology Student Chapter took the form of dinner meetings, motion picture meetings, and symposiums. A number of well-known engineers addressed the dinner meetings, and the motion pictures shown on other occasions did much to stimulate interest in various engineering projects. The symposiums took the form of weekly programs on subjects of modern interest. Members of the faculty and administration usually served as speakers for these sessions which were sponsored by the Chapter.

MICHIGAN COLLEGE OF MINING AND TECHNOLOGY

The eight meetings of the Michigan College of Mining and Technology Student Chapter held during the school year, 1933–1934, attracted a total attendance of 238. Members of the college faculty were the principal speakers at these meetings. An engineering float, consisting of a model of the George Washington Bridge, was entered in the winter carnival of the college. Among the other activities of the Chapter during the year was the sponsoring of two parties, at which dancing and cards formed the principal features of entertainment.

MICHIGAN STATE COLLEGE

Seminar courses in civil engineering were conducted as meetings of the Michigan State College Student Chapter during the school year, 1933–1934. There were 22 of these meetings, with a total attendance of 750. The programs for such sessions consisted largely of the presentation of student papers.

MISSOURI SCHOOL OF MINES AND METALLURGY

In the school year 1933–1934, the Missouri School of Mines and Metallurgy Student Chapter had 100 per cent enrolment of those in the school eligible for membership. Papers presented by the students formed a stimulating part of the meeting programs. Among the outside speakers who addressed sessions were J. C. Pritchard, treasurer of Russell and Axon of St. Louis; E. M. Stayton, Street Railway Commissioner of Kansas City, Mo.; C. L. Sadler, Topographic Engineer, U. S. Geological Survey; and J. H. Porter, consulting engineer of St. Louis, Mo.

MONTANA STATE COLLEGE

The annual report of the Montana State College Student Chapter states that in the school year 1933–1934 the Chapter had a 100 per cent membership of those eligible to join. The Chapter makes a practice of reserving one hour a week for its meetings, which furnish an excellent opportunity for the students to express themselves on engineering subjects. In fact, 30 papers were prepared and presented by them during the year.

NEWARK COLLEGE OF ENGINEERING

In the past year the Newark College of Engineering Student Chapter increased the number of its meetings from eight to eleven, and the average attendance at meetings showed a similar advance. The Chapter was active in the organization of the Conference of the Metropolitan Student Chapters. Among the outside speakers who addressed the technical sessions held during the year were Robert Ridgway, Past-President of the Society; Russell Wise, consulting engineer of Passaic, N.J.; Chester Mueller, Principal Assistant Engineer of the New Jersey Department of Public Affairs; and Victor Gelineau, chief engineer and director of the New Jersey State Board of Commerce and Navigation.

NEW MEXICO STATE COLLEGE

Illustrated lectures loaned by the Society formed the nucleus of entertainment at meetings of the New Mexico State College Student Chapter held during the past year. The largest and most successful meeting took place in April when the New Mexico Section of the Society was entertained by the Chapter. There were 14 other meetings during the year. The program on these occasions consisted largely of the presentation of papers prepared by the students.

NEW YORK UNIVERSITY

A varied program of entertainment and instruction characterized the activities of the New York University Student Chapter during the past school year. Dinners and smokers proved popular social events, and an interesting series of technical meetings was also enjoyed. Among the outside speakers appearing at such sessions were Reuben Boblow, with Robinson and Steinman, of New York, N.Y., and Charles Carswell, assistant engineer of the Port of New York Authority.

NORTH CAROLINA STATE COLLEGE OF AGRICULTURE AND ENGINEERING

The North Carolina State College of Agriculture and Engineering Student Chapter held 14 meetings during the 1933–1934 school year. Among the outside speakers who were heard at some of these sessions were T. S. Johnson and W. C. Olsen, consulting engineers of Raleigh, N.C. On April 28, 1934, the Chapter attended a meeting of the North Carolina Section of the Society held in Pinehurst. Another activity of interest was the annual Engineers' Fair, which was sponsored by the Chapter and the other engineering departments at the college.

NORTH DAKOTA STATE COLLEGE

The four meetings of the North Dakota State College Student Chapter held during the past year attracted a total attendance of 118. At the meeting that took place on December 7, 1933, a motion picture film of the *U.S.S. Macon* was shown through the courtesy of the Otis Elevator Company.

OHIO NORTHERN UNIVERSITY

Students and members of the faculty were the principal speakers at meetings of the Ohio Northern University Student Chapter held during the past school year. Several inspection trips were made to neighboring towns for the purpose of inspecting sewage treatment and water supply plants. Among the Ohio towns and cities visited were Delphos, Lima, Columbus, and Marion. Civil Engineers' Day was observed in February. On that occasion a talk on the topic, "Fire Protection Engineering," was given by Edmund J. Miessler, superintendent of the Ohio Inspection Bureau, and a film illustrating certain aspects of this subject was shown.

OHIO STATE UNIVERSITY

In addition to the routine business sessions, the Ohio State University Student Chapter enjoyed four dinner meetings and one lecture during the school year 1933–1934. The lecture was given by O. H. Ammann, Director of the Society and chief engineer of

the Port of New York Authority. Other interesting speakers addressed the dinner meetings. Among these were J. R. Smart, construction engineer for the Division of Water of Columbus, Ohio, and Willard T. Chevalier, publishing director for the McGraw-Hill Publishing Company, of New York, N.Y.

OREGON STATE COLLEGE

The 1933–1934 meetings of the Oregon State College Student Chapter were interesting and varied. Among the speakers heard at these sessions were H. A. Rands, a hydro-electric engineer for the U. S. War Department; Joseph A. Weber, president of the Northwest Section of Highway Engineers; L. T. Ross of the Corps of Engineers, U. S. Army; and R. R. Tinkham, Superintendent of Lighthouses for the 17th District. On May 19, 1934, which was engineers' day at Oregon State College, the Chapter acted as host to the Portland Section of the Society and to the Northwest Section of Highway Engineers.

PENNSYLVANIA MILITARY COLLEGE

Members of the Pennsylvania Military College Student Chapter had the privilege of hearing outside speakers at almost all their 1933–1934 meetings. Among those addressing these sessions were Lester L. Lessig, a contracting engineer with the McClintic-Marshall Corporation of Philadelphia; Joseph R. Farrell, a building contractor of Philadelphia; C. J. Tilden, Strathcona Professor of Engineering Mechanics at Yale University; and H. L. Kalbach, of the Portland Cement Association. Several joint meetings with the Student Chapters of neighboring colleges and universities were also enjoyed. Other pleasurable occasions during the year were inspection trips to the laboratories of the University of Delaware, the Sun Shipbuilding and Drydock Company's shipyard and engineering shop, and the Eddystone sewerage disposal plant.

PENNSYLVANIA STATE COLLEGE

Faculty members and engineering students of Pennsylvania State College cooperated to make the school year 1933–1934 an interesting one for the Pennsylvania State College Student Chapter by presenting a number of interesting papers at its meetings. In all, thirteen such meetings were held during the year with a total attendance of 564. Among the interesting activities of the Chapter was the publication of a mimeographed bulletin at regular intervals throughout the year. This sheet is called *The Penn State Tripod*.

POLYTECHNIC INSTITUTE OF BROOKLYN

The Polytechnic Institute of Brooklyn Student Chapter reports a 100 per cent enrolment of those eligible for membership during the past school year. There were 240 in attendance at the four meetings held by the Chapter. Inspection trips to the Rockville Center (Long Island) sewage treatment plant and to the Bethlehem Steel Works at Bethlehem, Pa., also proved of interest.

PURDUE UNIVERSITY

There were 780 present at the seven meetings of the Purdue University Student Chapter held in the school year 1933–1934. Members of the faculty were the speakers at most of these sessions, although on some occasions interesting motion pictures were also enjoyed. These films were shown through the courtesy of the U. S. Bureau of Reclamation and the Babcock Wilcox Company. On May 11, 1934, the Chapter sponsored a picnic at Ross Camp on the Wabash River for the whole civil engineering school.

RENSSELAER POLYTECHNIC INSTITUTE

Several well-known engineers addressed the 1934–1934 meetings of the Rensselaer Polytechnic Institute Student Chapter. These included D. B. Steinman, consulting engineer of New York, N.Y.; S. R. Russel, of the E. I. du Pont Company; and Robert Shippee, a member of Aerial Explorations, Inc. Other interesting sessions were addressed by members of the faculty.

RHODE ISLAND STATE COLLEGE

The school year 1933–1934 was unusually successful for the Rhode Island State College Student Chapter. The seven meetings held during the year attracted a total attendance of 199. Outside speakers and members of the Chapter presented papers on such occasions, and at one session five reels of motion pictures of the Mt. Hope Bridge were shown. These were loaned to the Chapter by S. E. Freswell, manager of the Mt. Hope Bridge Company.

ROSE POLYTECHNIC INSTITUTE

The 1933–1934 report of the Rose Polytechnic Institute Student Chapter shows a 100 per cent enrolment of engineering students eligible for membership. At the seven meetings held during the year varied programs were presented by students, members of the faculty, and outside speakers. Among those heard at these sessions were C. Hunnell, Jr., District Engineer of the Indiana State Highway Commission, and M. R. Keefe, manager of foreign operations for Ulen and Company during the construction of a water supply system for Athens, Greece. Mr. Keefe described this project.

RUTGERS UNIVERSITY

During the past school year the Rutgers University Student Chapter enjoyed several interesting meetings. Among the outside speakers who addressed these sessions were Morris Goodkind, Bridge Engineer of the New Jersey State Highway Commission; Charles Capen, engineer for the North District Water Supply Commission; and Allen P. Richmond, Jr., assistant to the Secretary of the Society. On May 10 an inspection trip was made to the Wanaque Dam.

SOUTH DAKOTA STATE COLLEGE

The recently organized South Dakota State College Student Chapter held twelve meetings during the year 1933–1934 school year. These sessions, which attracted a total attendance of 219, were devoted to the presentation of papers by students and members of the faculty and of illustrated lectures loaned by the Society. Among the social events sponsored by the Chapter were an engineers' smoker and a dance.

STANFORD UNIVERSITY

An unusually large number of meetings were held by the Stanford University Student Chapter during the past school year. In fact there were 23 of these technical sessions, besides special inspection trips. A two-day trip was made to Boulder Dam for the purpose of inspecting construction aspects of the project. Other inspection trips included the site of Parker Dam, the San Francisco-Oakland Bay Bridge, and the Metropolitan Aqueduct project. Numerous interesting speakers addressed the various meetings, the list including Nathan Bowers, president of the San Francisco Section of the Society; E. W. Kramer, Regional Engineer, U. S. Forest Service and Federal Power Commission; Donald R. Warren, Senior Bridge Field Engineer on the construction of the San Francisco–Oakland Bay Bridge; and J. D. Galloway, consulting engineer of San Francisco.

STATE COLLEGE OF WASHINGTON

The 1933–1934 meetings of the Washington State College Student Chapter were devoted largely to the presentation of papers by students and members of the faculty. At some of the sessions use was also made of the illustrated lectures loaned by the Society. In all there were 13 meetings, which drew an attendance of 287.

STATE UNIVERSITY OF IOWA

Students addressed a number of the 1933–1934 meetings of the State University of Iowa Student Chapter, and motion pictures describing current engineering projects were shown at others. Some of these sessions were held jointly with meetings of local student branches of the American Society of Mechanical Engineers and the American Society of Military Engineers. Several outside speakers were also heard. These included Stanley Herald, mechanical engineer and geologist; C. H. Currie, president of the Iowa Section of the Society and chairman of the Iowa State Board of Engineering Examiners; and Major Wheeler, District Engineer of the Rock Island Engineering District. In the spring an inspection tour of the Rock Island Arsenal, Dam, and Locks was made.

SWARTHMORE COLLEGE

Members of the Swarthmore College Student Chapter presented weekly papers during the past school year, receiving one hour of engineering credit for this work. Six large meetings, with outside speakers, were also held. Among these speakers were Dexter S. Kimball of the administration staff of Cornell University; Willard T. Chevalier, publishing director of the McGraw-Hill Publishing Company; and Charles J. Tilden, Strathcona Professor of Engineering Mechanics at Yale University.

SYRACUSE UNIVERSITY

The annual report of the Syracuse University Student Chapter shows a 100 per cent enrolment of those eligible for membership. The 14 meetings held during the school year boasted a total attendance of 600. Among the outside speakers who addressed these sessions were A. E. Crockett of the Jones and Laughlin Steel Corporation of Pittsburgh, Pa., and Raymond B. Traver, Highway Superintendent of Onondaga County. Illustrated lectures loaned by the Society were enjoyed at some of the meetings, and at other sessions motion pictures were shown through the courtesy of the Hanna Engineering Works of Chicago.

TEXAS TECHNOLOGICAL COLLEGE

Illustrated lectures furnished by the Society and motion pictures loaned by the U. S. Department of the Interior formed the nucleus of entertainment at meetings of the Texas Technological College Student Chapter held during the past year. Several interesting lectures given by members of the faculty were also enjoyed, and the annual banquet was the occasion of the formal installation of officers.

TUFTS COLLEGE

Several interesting meetings were held by the Tufts College Student Chapter during the past school year. The list of speakers at these sessions included Albert E. Kleinert, Jr., Assistant Structural Engineer in the Department of Public Works, Commonwealth of Massachusetts, and J. P. Den Hartog, of the staff of Harvard University. At one meeting a film was shown through the courtesy of Stone and Webster. Several social events, including a smoker and buffet supper, were also enjoyed.

TULANE UNIVERSITY

The first annual report of the Tulane University Student Chapter indicates that this newly organized Chapter enjoyed a very interesting and successful year. In all there were thirteen meetings, with a total attendance of 612. The list of speakers at these sessions included the following: Douglas S. Anderson, dean of the College of Engineering of the university; John F. Coleman, Past-President of the Society; E. N. Noyes, Director of the Society; and Harvey N. Davis, president of Stevens Institute of Technology. Inspection trips were made to several local projects of engineering interest, such as the mill of the Lone Star Cement Company; the shops and repair yards of the Southern Pacific Railroad at Algiers, La.; and the site of the Huey P. Long Bridge, now under construction across the Mississippi River just above New Orleans.

UNIVERSITY OF AKRON

Several interesting meetings were enjoyed by the University of Akron Student Chapter in the school year, 1933–1934. Some of the sessions were addressed by members of the Chapter, and others were devoted to the showing of motion picture films on subjects of current engineering interest. On one occasion E. A. Zeisloft, of the Metropolitan Brick Company, of Canton, Ohio, was guest speaker. In January the entire Chapter attended the annual dinner meeting of the Cleveland Section.

UNIVERSITY OF ALABAMA

During the past school year the University of Alabama Student Chapter held twelve meetings, which attracted a total attendance of 286. Entertainment on these occasions was divided between the presentation of papers by students, members of the faculty, and outside speakers. Several of the Society's illustrated lectures were also enjoyed.

UNIVERSITY OF ARIZONA

Several of the 1933–1934 meetings of the University of Arizona Student Chapter were held jointly with sessions of the Arizona Section of the Society. Among the interesting speakers heard during the year were Hunter McDonald, Past-President of the Society; G. H. Atchley, superintendent of construction for the Jones and Laughlin Steel Corporation; and L. M. Lawson, commissioner of the U. S. International Boundary Commission.

UNIVERSITY OF ARKANSAS

The annual report of the University of Arkansas Student Chapter for the past school year shows a 100 per cent enrolment of those eligible for membership. Papers prepared by the students were presented at almost all of the 14 meetings held during the year. Illustrated lectures loaned by the Society were also in great demand for these occasions, and motion pictures shown through the courtesy of commercial organizations likewise proved popular.

UNIVERSITY OF CALIFORNIA

The University of California Student Chapter reports that the past school year was a complete success from every standpoint. There were four meetings, with a total attendance of 305. Each of these was preceded by a dinner, and each was notable for the interest and variety of its technical program. Among the projects of engineering interest visited during the year were the plant of the U. S. Steel Corporation in Pittsburgh, Calif.; the San Francisco–Oakland Bay Bridge; and the Golden Gate Bridge.

UNIVERSITY OF CINCINNATI

The University of Cincinnati Student Chapter reports that the 1933–1934 school year was a successful one and that the Chapter had a 100 per cent enrolment of those eligible for membership. In all there were five meetings, which drew a total attendance of 243. Among the outside speakers were H. H. Kranz, Superintendent of Highway Maintenance for the City of Cleveland, and J. S. Raffety, Sanitary Engineer of Hamilton County, Ohio.

UNIVERSITY OF COLORADO

Student lectures proved popular and interesting at the meetings of the University of Colorado Student Chapter held during the past school year. Among the outside speakers appearing at these sessions were Lester Varian, a Denver architect, and Charles E. Thomas, president of the Colorado State Board of Examiners for Architects. In March the Chapter sponsored a seven-day inspection trip to Boulder Dam. A report on this trip was made at a special meeting of the Chapter.

UNIVERSITY OF DAYTON

The University of Dayton Student Chapter had a 100 per cent enrolment of those eligible for membership during the past year. Most of the papers presented at the nine meetings that were held were prepared by students. Among the projects visited on engineering trips during the year were the plant of the Wabash Cement Company; the local CWA work of an engineering nature; the various bridges in the city of Dayton; and a local radio broadcasting station.

UNIVERSITY OF FLORIDA

Students and members of the faculty presented papers at most of the 1933–1934 meetings of the University of Florida Student Chapter. On one occasion Maj. O. F. Lange of the Corps of Engineers, U. S. Army, gave a talk on the topic, "Engineering as Related to Warfare." The Chapter participated actively in an engineers' fair, which was held on the campus, and was also one of the sponsors of the annual engineers' field day.

UNIVERSITY OF IDAHO

Members of the faculty addressed most of the 1933–1934 meetings of the University of Idaho Student Chapter on various timely engineering topics. At the beginning of the school year a civil engineers' picnic was given for the purpose of interesting new students in the Chapter. The Chapter also took an active part in the annual engineers' show, which was staged by all the engineering societies at the university.

ITEMS OF INTEREST

Engineering Events in Brief

CIVIL ENGINEERING for November

AFTER a number of years of use, a hide-curing warehouse in Los Angeles was found to have suffered considerable damage from the concentrated solution of sodium chloride used in the curing process. The building was of reinforced concrete but the solution had seeped through the outer layer of concrete, attacked the steel, and seriously menaced the structure. In the November number, D. H. McCreery, Assoc. M. Am. Soc. C.E., writes of the investigation which revealed the damage, discusses the probable causes, and explains the steps taken to repair the building and prevent future difficulty of the same type. All the work of investigation and repair was under his direction.

A short symposium on the use of dimensionless numbers as related to hydraulic model studies has been prepared for November. The two authors, R. W. Powell, M. Am. Soc. C.E., and Hunter Rouse, of Columbia University, are painstaking students of this subject, which is assuming increasing importance to engineers. Their articles emphasize some of the pitfalls that should be avoided in applying Reynolds, Froude, and Weber numbers to experiments with models and point out the need of using care in model experimentation to be certain that all the conditions of flow are considered in making the mathematical analysis.

Readers will be interested to know that another article by Lynn Perry on boundaries is planned for November. His previous article, in the June number, traced the Maryland–West Virginia boundary controversy back to its beginnings in the reign of Charles I. In the forthcoming article, he deals with the unique circular boundary of Delaware, which goes back to the same period. It was established at the request of James II while he was Duke of York and was first surveyed by Taylor and Pierson in 1701 under authorization of William Penn. The corner common to Delaware, Maryland, and Pennsylvania was marked by Mason and Dixon in 1765. A part of the work of these famous surveyors had some influence on the Delaware arc as finally ratified by Congress in 1921.

Contrary to precedent in that state, a tall building in Texas built in 1928 was founded on a reinforced concrete mat resting on plastic clay instead of a group of precast concrete piles. A study of the situation, by Willard E. Simpson, Assoc. M. Am. Soc. C.E., in the light of field tests and previous experience with the same soil indicated that the action of driving the piles would so disturb the stability of the clay as to detract materially from its ability to carry the load. Time-settlement curves on the building made during construction and since completion have indicated the accuracy of these assumptions as to settlement. This and other interesting experiences and observations of Mr. Simpson relating to foundations on Texas soils form the basis of his article to appear in November.

On a New Mexico irrigation and drainage project it was found necessary to drop a maximum of 400 cu ft per sec of water at the end of a canal back to the Rio Grande River, a fall of 86 ft. The problem of absorbing the energy of the water, falling at a theoretical velocity of 64 ft per sec, amounting to some 4,000 hp, was solved after a series of laboratory tests on models built to a scale of 1:15. As a result, a lined wasteway, of trapezoidal section, 12 ft deep and 12 ft wide at the bottom, was built on a slope of nearly 12 ft per 100 ft of length. In it there are V-shaped cross walls 5 ft high and about 40 ft apart. The angle of the "V" points upstream so that the whole structure forms a succession of drops or cascades which effectually retard the velocity of the water and absorb its energy. The laboratory tests for this structure made by W. R. Barrows, Jun. Am. Soc. C.E., and A. W. Newcomer in the hydraulic laboratory of the University of New Mexico, form the subject of the article by them to appear next month.

Centenary of Telford's Death

Famous English Engineer Gave His Name to Type of Road Construction

ON SEPTEMBER 2, the one hundredth anniversary of the death of Thomas Telford, the Institution of Civil Engineers paid tribute to his genius. On Telford's tomb in one of the chapels of Westminster Abbey a wreath was laid and at the memorial seat erected at Westerkirk, in Eskdale, Dumfriesshire, where he was born in 1757, another wreath was placed.

THOMAS TELFORD, 1757–1834
Frontispiece from "*Lives of the Engineers*" by Samuel Smiles

Son of a Dumfriesshire shepherd, Telford was apprenticed to a stonemason, but found time for literature. He wrote some poems which earned the praise and lifelong friendship of Southey. In 1782 he went to London, where he was employed on the erection of Somerset House, the finest piece of architectural work then in progress in the city. Later he was appointed Surveyor of Public Works for the county of Salop. In 1793 he was appointed engineer for the Ellesmere Canal, for navigation between the Severn, the Dee, and the Mersey rivers. As a part of this work, he built the remarkable Chirk and Pont-y-Cysyllte aqueducts. Here he gained a reputation as a canal engineer and later embarked on the more ambitious project of constructing the Caledonian Canal in the highlands of Scotland.

During his service as engineer to the Parliamentary Commission (1802–1822) he made an extensive survey of the roads of Scotland. As a result of his report he there directed the building of 920 miles of highways, requiring upward of 1,200 bridges. These opened up the hitherto inaccessible interior of Scotland to commercial and agricultural intercourse. It was here that he developed the type of roadmaking that perpetuates his name. His success as a road builder made his services in demand for many years on roads radiating from London to Scotland, Wales, and Ireland. His advice was frequently sought abroad, particularly in Russia, Austria, and Sweden on roads, bridges, and canals.

His canal- and road-building activities required frequent bridges. Telford's more noted ones are the Menai Bridge and the Conway Bridge, both suspension spans of the chain type and both completed in 1826. In addition to these activities his talent was in demand for dock and harbor construction and for the drainage of 100,000 acres in the eastern part of the Fens. Although he made use of railways for the construction of his works he declined to enter into the general construction of them as lines of communication when their use became general, about 1825. He was then at the age of 70 and wished to restrict rather than expand his activities. Further he felt that he could not, in justice to his former employers, engage on work which would compete with the canals he had spent so many years of his life in building.

In 1820 Telford accepted the office of first president of the newly formed Insti-

tution of Civil Engineers. He aided materially in obtaining its charter of incorporation, granted in 1828, and until his death devoted much energy to its welfare. His last work was the plan for the improvement of the Dover Harbor, which was carried to completion after his death. The later years of his life were devoted to completing the record of his many engineering projects.

Writing to a friend in 1830 concerning a young man who desired to enter the engineering profession, Telford expressed his opinion that the young man should not be encouraged to become an engineer because the profession was crowded and offered few prizes in proportion to the large number of blanks. He maintained that there was no short path to distinction. However, if civil engineering still was preferred, his advice was that the young man should engage himself as an apprentice in some practical employment at hard labor by which means he could secure a first-hand familiarity with the materials of construction, acquire manual skill, and gain a knowledge of the habits and dispositions of the workmen who carry out the engineer's designs. "For my own part," he wrote, "I may truly aver that 'steep is the ascent, and slippery is the way.'"

Hardness of Public Water Supplies in the United States

WATER-SUPPLY PAPER No. 658 of the Geological Survey, U. S. Department of the Interior, has just been issued. In it the chemical composition of the public water supplies of 670 places, which serve 56,000,000 consumers, is shown in a 98-page table. In the table the supply systems are described briefly as to source and treatment. The accompanying text carries a brief discussion of the treatment of public, industrial, and domestic supplies, without reference to questions relating to sanitation and health. Data for the individual supplies, especially with reference to hardness, are summarized in several smaller tables. A map indicates the weighted average hardness, by states, of the supplies for which analyses are given. This paper is for sale by the Superintendent of Documents, Government Printing Office, Washington, D.C., for 15 cents.

Specifications for Asphalt Road Construction

NINE PAMPHLETS, containing construction specifications for as many asphalt road types, have been issued by the Asphalt Institute in 5 by 7-in. size. They include various surface courses, surface treatments, base materials, and road mixes.

These specifications, as they relate to surface treatment and road-mix types, show in detail the best low-cost road construction practices, as previously covered broadly in the Institute's Road Construction Manuals. The hot-mix and penetration types are recent revisions of earlier Asphalt Institute specifications with more detailed requirements covering improved equipment. Copies of these construction specifications will be sent on request without charge by the Asphalt Institute, 801 Second Avenue, New York, N.Y.

How to Build Cement-Bound Macadam Roads

A BOOKLET entitled *Cement Bound Macadam* has recently been issued, which contains the accumulated experience of the past few years in the construction of a rapidly growing yardage of this pavement. It also incorporates the findings of the Elmhurst test road, which were summarized in a companion booklet issued in June. The chapter on design gives particular attention to the selection of aggregates, the latitude possible in the use of available materials being an important advantage of this type of pavement. The design of grout and methods of grouting are fully discussed. The first reliable table for estimating quantities of material is also included. The remainder of the book is given over to construction methods and specifications.

Interested engineers may obtain copies free on request to the Portland Cement Association, 33 West Grand Avenue, Chicago.

NEWS OF ENGINEERS

From Correspondence and Society Files

WILLIAM W. LEWIS, formerly assistant engineer in the Transit Department of the City of Boston, recently retired after a continuous service of nearly forty years on the construction of a subway system for that city.

EUGENE E. HALMOS is now serving as resident engineer for Parsons, Klapp, Brinckerhoff, and Douglas on the Sutherland Project at North Platte, Nebr.

S. C. HOLLISTER, former Professor of Structural Engineering at Purdue University, was recently appointed director of the School of Civil Engineering at Cornell University.

STANLEY E. SPORSEEN is now engaged as a structural draftsman by the U. S. Engineers on the Bonneville Project, at Bonneville, Ore.

WILLIAM R. DUNHAM, JR., has severed his connection with the Chicago and Calumet Transit Company, of Hammond, Ind., to accept a position with the Department of Street Railways of the City of Detroit.

ROY W. CARLSON has been appointed Assistant Professor of Civil Engineering at the Massachusetts Institute of Technology. He was former y research engineer in the Engineering Materials Laboratory of the University of California.

BENSON J. WOOD has taken a position as transitman with the Michigan State Highway Department, with headquarters in Port Huron, Mich.

F. E. TRASK has been promoted from the position of State Engineer of the Public Works Administration of California to that of member of the Board of Review of the Public Works Administration in Los Angeles, Calif.

WILLIAM HOBBS, JR., is now a student engineer with the John A. Roebling's Sons Company. in Trenton, N.J.

WILLIAM OEHRLE has accepted a position as construction engineer in the Procurement Division of the Public Works Branch of the U. S. Treasury Department, with offices in Malone, N.Y. He was formerly resident engineer for the Public Works Administration of South Carolina.

B. B. BRIER, formerly assistant treasurer for the Morgan Engineering Company. of Harlingen, Tex, is now on the staff of the Tennessee Valley Authority, with headquarters in Knoxville, Tenn.

ROSS N. BRUDENELL has entered the employ of the Tennessee Valley Authority, with headquarters in Knoxville, Tenn. He was formerly in the Hydraulic Laboratory of the University of Iowa, at Iowa City, Iowa.

CHARLES A. SELBY has become a partner in the firm of Wininger and Selby, Inc., general contractors, of 152 West 42d Street, New York, N.Y.

HERBERT D. VOGEL, 1st Lieutenant U.S. Army, has been detailed from the U. S. Waterways Experiment Station at Vicksburg, Miss., to the Command and General Staff School at Fort Leavenworth, Kans.

LA MARTINE D. GILFILLAN has been made specification examiner in the Division of Engineering of the U. S. Department of the Interior, in Washington, D.C.

GEORGE F. NICHOLSON, until recently harbor engineer for the Los Angeles Harbor, has established a consulting engineering practice at 1116 Insurance Exchange Building, Los Angeles, Calif., where he will specialize in harbor work.

W. T. E. BARBER is now associated with the Lotz Insulation Company, of Hartford, Conn. He was formerly with the Truscon Steel Company, of Youngstown, Ohio.

ODD ALBERT has joined the staff of New York University in the capacity of faculty lecturer on advanced design of structures.

CARLETON W. LOVELL, formerly an engineer with the Mason and Hanger Company, Inc., of New York, N.Y., is now resident engineer inspector for the Tri-

borough Bridge Authority, of the same city.

R. L. VAUGHN is now employed by the Merritt-Chapman and Scott Corporation, with headquarters in San Pedro, Calif.

CHARLES S. JOSLYN has severed his engineering connection with Marc Eidlitz and Son, Inc., of New York, N.Y., to accept a position in the U. S. Engineers Office, at Glasgow, Mont.

Changes in Membership Grades

Additions, Transfers, Reinstatements, Deaths, and Resignations

From August 10 to September 9, 1934, Inclusive

ADDITIONS TO MEMBERSHIP

BECHTEL, STEPHEN DAVISON (Assoc. M. '34), Executive Representative, W. A. Bechtel Co., Inc. and Subsidiaries, 155 Sansome St., San Francisco, Calif.

BOTTIGER, ANDREW JALMER (Assoc. M. '34), Engr.-in-Chg., Sales and Design, Sherman Concrete Pipe Co. (Res., 115 East Gill St.), Knoxville, Tenn.

CALDERÓN, ANTONIO (Jun. '34), Insp., U. S. Engr. Office, San Juan, Puerto Rico.

CALLAHAN, SAMUEL JOSEPH (Assoc. M. '34), Constr. Engr. for County Court, Jackson County; Cons. Engr. (Res., 7245 Jefferson), Kansas City, Mo.

CAMPBELL, RICHARD TRENT (Jun. '34), Instrumentman, State Highway Dept., 1621 Ave. Y, Lubbock, Tex.

CARD, FRANCIS CHARLES (Jun. '34), Computer, U. S. Coast and Geodetic Survey (Res., 12 Fifth Ave.), New York, N.Y.

CARLETON, ROBERT ANDREW WOOD (M. '34), Pres., Gen. Mgr. and Engr. in Chg., The Carleton Co., Inc., 500 Fifth Ave., Room 3828, New York, N.Y.

CHAMBERLAIN, ANTONIO ARRILLAGA (Assoc. M. '34), Junior Asst. Engr., Grade 2, State Dept. of Public Works, Div. of Eng., Albany (Res., Glen Mary, Catskill), N.Y.

COHN, MORRIS MANDEL (Assoc. M. '34), San. Engr., Dept. of Public Works (Res., 1101 Lexington Ave.), Schenectady, N.Y.

COMM, EDWARD DANIEL (Jun. '34), Field Engr., FERA (Res., 411 Ave. E.), Bismarck, N. Dak.

CONESA, HAMLET PEDRO (Assoc. M. '34), Engr. in Chg., Central Mercedita, Ponce, Puerto Rico.

CONROY, JOHN TIMOTHY (Assoc. M. '34), Engr. of Constr., City of Dallas (Res., 106 North Clinton Ave.), Dallas, Tex.

COOMBE, JOHN VAN VEGHTEN (Jun. '34), 7106 Sheridan Rd., Chicago, Ill.

CULLINAN, ROY BERNARD (Jun. '34), With State Highway Eng. Dept., 27 Platts St., North Abington, Mass.

DANDA, FRANK ANTHONY (Assoc. M. '34), Civil Engr., San. Dist. of Chicago, 910 So. Michigan Ave., Chicago (Res. 1809 South 58th Court, Cicero), Ill.

GEE, ROBERT EUGENE (Jun. '34), 4018 Beechwood Pl., Riverside, Calif.

GELABERT D'ELIAS, RAMÓN (Jun. '34), Asst. Engr., Am. R. R. Co. of Puerto Rico, San Juan, Puerto Rico.

GOODHEART, EDMUND JAMES (Assoc. M. '34), Teacher, Math., Excelsior Union High School, Norwalk, (Res. 537 Artesia Boulevard, Bellflower), Calif.

HATHAWAY, GAIL ABNER (M. '34), Senior Engr., U. S. Engr. Dept., 610 Postal Telegraph Bldg., Kansas City, Mo.

HOGAN, FRANK (Assoc. M. '34), 415 Lexington Ave., Room 1111, New York, N.Y.

KENDALL, NATHANIEL JAMES (Jun. '34), Box 73, Los Altos, Calif.

KNOLL, CARL ALVIN (Jun. '34), Junior Engr., Met. Water Dist. of Southern California; 1538 North Alexandria Ave., Los Angeles, Calif.

LANGAN, JOHN ALBERT (Assoc. M. '34), Dist. Field Engr., Temporary Emergency Relief Administration; 437 West Genesee St., Syracuse, N.Y.

LAWRENCE, CHARLES (Assoc. M. '34), Senior Draftsman, State Highway Dept.; 593 Larchwood Ave., Upper Darby, Pa.

LEONARD, JOHN JOSEPH (Jun. '34), Bldg. Contr. (J. J. Leonard & Son) (Res., 1158 Dolores St.), San Francisco, Calif.

LEWIS, CHARLES ALEXANDER, JR. (Assoc. M. '34), Engr. and Contr. (Lewis Bros.) (Res., 339 West Lynwood St.), Phoenix, Ariz.

LOWRY, ROBERT LEE, JR. (Assoc. M. '34), Technical Asst., State Reclamation Dept., 4015 Ave. D, Austin, Tex.

MASK, WALTER SHARMAN (Jun. '34), Insp., U. S. Engrs., 2d New Orleans River Dist. (Res., 604 St. Ferdinand St.), Baton Rouge, La.

MULHOLLAND, ANDREW NEWELL (Assoc. M. '34), 3525 Decatur Ave., New York, N.Y.

OSTOIA, VLADIMIR KRZYWIEC (M. '34), 7 West 108th St., Apartment 6 B, New York, N.Y.

PETERSEN, LAWRENCE CHRISTIAN (M. '34), Designer, Bridges and Structures, State Highway Comm. (Res., 42 Laurel Ave.), Trenton, N.J.

PETRENKO, METHODY PAUL (Assoc. M. '34), Engr., Civ. Works Administration, Secaucus (Res., 203 Academy St., Jersey City), N.J.

PORRATA DORIA, FRANK LUIS (M. '34), Cons. Engr., City of Ponce, Box 222, Ponce, Puerto Rico.

POTTS, HARRY LATELLE (M. '34), Engr., Denver Municipal Water Works (Res., 1344 South Pearl St.), Denver, Colo.

RAYMOND, SENIUS JOHN (Assoc. M. '34), Capt., Q.M.C., U.S.A., Fort George G. Meade, Md.

RIDGWAY, JAMES WILLIAM (Assoc. M. '34), Asst. Borough Engr., Richmond County, for Civ. Works Administration; 1626 East 38th St., Brooklyn, N.Y.

SAMUEL, THOMAS DUNCAN, III (Assoc. M. '34), Draftsman, Black & Veatch, Mutual Bldg. (Res., 442 West 68th St.), Kansas City, Mo.

TAYLOR, JAMES ELLIOTT (Jun. '34), Res. Engr., State Highway Dept., Post (Res., 2223 Tenth St., Lubbock), Tex.

TAYLOR, PHILIP WESTON (M. '34), Asst. Engr., Metcalf & Eddy, 1300 Statler Bldg., Boston (Res., 10 Riverdale Rd., Wellesley Hills), Mass.

THORNER, IRVING BERNARD (Assoc. M. '34), 536 West 111th St., New York, N.Y.

TORIBIO, SIMEÓN GALVEZ (Jun. '34), Care, Philippine Amateur Athletic Federation, Manila, Philippine Islands.

WICKSTROM, WICK (Assoc. M. '34), Chf. Engr., Warren & Arthur Smadbeck, Inc., 17 West 56th St., New York, N.Y.

WILSON, HARVEY ASHTON (Assoc. M. '34), Field Supt., Jefferson Lake Oil Co., Box 152, Calexico, Calif.

WISEMAN, EUGENE ROLAND (M. '34), Asst. Prof., Dept. of Civ. Eng., Rensselaer Polytechnic Inst., Troy (Res., 321 Seventh Ave., North Troy), N.Y.

WRIGHT, ROBERT ERNEST (Assoc. M. '34), 497 West Grandview Ave., Sierra Madre, Calif.

YOUNG, CHARLES AUGUSTUS (Assoc. M. '34), Junior Engr., U. S. Geological Survey, 207 Federal Bldg., Fort Smith, Ark.

TOTAL MEMBERSHIP AS OF SEPTEMBER 9, 1934	
Members	5,708
Associate Members	6,064
Corporate Members	11,772
Honorary Members	17
Juniors	2,861
Affiliates	98
Fellows	4
Total	14,752

MEMBERSHIP TRANSFERS

BENES, EDWARD WILLIAM (Jun. '26; Assoc. M. '34), Asst. Engr., A Burton Cohen, 1 Madison Ave., New York (Res., 50 Darwood Pl., Mount Vernon), N.Y.

BUCK, HENRY WOLCOTT (Jun. '25; Assoc. M. '34), Secy. and Treas., Henry Robinson Buck, Inc., 650 Main St., Hartford (Res., 570 Wolcott Hill Rd., Wethersfield), Conn.

GREGOR, MICHAEL (Assoc. M. '28; M. '34), Executive Engr., Seversky Aircraft Corporation, 570 Lexington Ave., Room 2511 (Res., 5 Prospect Pl., Tudor City), New York, N.Y.

HALL, LESTER GEORGE (Jun. '31; Assoc. M. '34), Computer, Plans Dept., State Highway Dept., Pierre (Res., 221 Eighth Ave., S.E., Aberdeen), S. Dak.

JOYNT, PHILIP DONNELLY (Jun. '26; Assoc. M. '34), Salesman, Bethlehem Steel Co., Philadelphia (Res., 404 Cherry Lane, Merwood Park), Pa.

KRIEGSMAN, EUGEN FREDERICK (Jun. '08; Assoc. M. '14; M. 34), Cons. Engr., 212 Pawtuxet Ave., Edgewood, R.I.

LAVERTY, FRANCIS JOHN (Jun. '25; Assoc. M. '28; M. '34), Project Engr., Westchester County San. Sewer Comm., 158 Martine Ave., White Plains (Res., R.D., 164 Pleasantville Rd., Briarcliff), N.Y.

MEGGITT, SAMUEL EDWARD (Jun. '24; Assoc. M. '34), Senior Asst., B. L. Hurst, 274, Watford Way, Hendon, London, N. W. 4, England.

PERLITER, SIMON (Jun. '25; Assoc. M., '34), Asst. Engr., Met. Water Dist. of Southern California (Res., 927 Heliotrope Drive), Los Angeles, Calif.

ROBERTS, PAUL OSBORNE (Jun. '31; Assoc. M., '34); Box 124, Moorhead, Miss.

REINSTATEMENTS

AXELSON, EVERT ALEXIS, Jun., reinstated Sept. 6, 1934.

HUGHES, CONRAD PERCY, Assoc. M., reinstated Sept. 6, 1934.

TALMADGE, EZRA EDWIN, M., reinstated Sept. 6, 1934.

RESIGNATIONS

GLENN, WILLIAM DAVID, Jun., resigned Sept. 1, 1934.

LEWIS, CHESTER FRANKLIN, M., resigned Aug. 28, 1934.

SPOWART, ROBERT JAMES, Jun., resigned Sept. 6, 1934.

DEATHS

BROWNE, GEORGE HAMILTON. Elected M., Sept. 3, 1884; died Aug. 30, 1934.

BUCK, HENRY ROBINSON. Elected Jun., June 5, 1900; Assoc. M., Oct. 4, 1905; M., Feb. 4, 1908; died Aug. 11, 1934.

CAHILL, WALTER JOHN. Elected M., June 6, 1906; died Aug. 8, 1934.

CAHN, ALEXANDER. Elected M., July 11, 1921; died Aug. 27, 1934.

DAVIS, ROBERT BENJAMIN. Elected M., July 3, 1889; died July 31, 1934.

FRANCIS, JOSEPH INGHAM. Elected Jun., Oct. 26, 1931; died Aug. 22, 1934.

GOODWIN, ELMER CLARK. Elected Assoc. M., Oct. 1, 1926; died Aug. 18, 1934.

LOVELL, FREDERICK WILLIAM. Elected M., June 6, 1906; died July 25, 1934.

PERKINS, CHARLES PENROSE. Elected Jun., Feb. 3, 1875; M., Apr. 5, 1882; died Aug. 19, 1934.

RICE, HERBERT ALLAN. Elected Assoc. M., June 7, 1905; died July 28, 1934.

SCHUYLER, PHILIP KINGSLAND. Elected Assoc. M., May 28, 1923; M., Apr. 22, 1929; died May 29, 1934.

SMITH, BURTON. Elected M., Oct. 1, 1913; died June 10, 1934.

SULLIVAN, JOHN FRANCIS. Elected Assoc. M., Jan. 4, 1910; M., Feb. 4, 1914; died Aug. 14, 1934.

THOMAS, BURTIS PAUL. Elected Assoc. M., Jan. 14, 1924; died June 28, 1934.

Men Available

These items are from information furnished by the Engineering Societies Employment Service, with offices in Chicago, New York, and San Francisco. The Service is available to all members of the contributing societies. A complete statement of the procedure, the location of offices, and the fee is to be found on page 85 of the 1934 Year Book of the Society. To expedite publication, notices should be sent direct to the Employment Service, 31 West 39th Street, New York, N.Y. Employers should address replies to the key number, care of the New York Office, unless the word Chicago or San Francisco follows the key number, when the reply should be sent to the office designated.

CONSTRUCTION

STRUCTURAL ENGINEER; Assoc. M. Am. Soc. C.E.; graduate; 33; married; registered in Illinois; 10 years experience in the design and construction of factory buildings, ore docks, mining buildings and hydraulic works for gold mining company, including 4 years on railroad and highway bridges, fixed and bascule. Available immediately. D-3311.

ENGINEER; M. Am. Soc. C.E.; 51; married; New York State license; 30 years experience on the construction of subways and tunnels, with city, and as chief engineer and consulting engineer for contractors. Plant layout and costs, preparation of bids, organization and control of work in field and office. D-3326.

CIVIL AND STRUCTURAL ENGINEER; Assoc. M. Am. Soc. C.E.; 31; married; registered civil engineer; experience in surveys, construction, and maintenance of fixed and movable bridges, highways, and sewers. Completely familiar with the construction of double-leaf bascule bridges. Location immaterial. Available immediately. D-3353.

DESIGN

STRUCTURAL AND MUNICIPAL ENGINEER; Assoc. M. Am. Soc. C.E.; graduate C.E.; 15 years experience. Experienced designer, estimator, and superintendent, principally architectural engineering and sewage disposal. Competent to limited extent on mechanical installations, heating and refrigeration, pumps and conveying machinery. Also considerable experience in heavy railroad design and movable bridges and cranes. Will go anywhere including abroad. C-2701.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; 30; B.S. in C.E.; 1 year field and office work on topography surveys; 4½ years varied structural experience on bridges, including investigations of stresses and capacities, and reinforcement of various types of highway and railroad bridges. References. Available immediately. D-2574.

EXECUTIVE

LICENSED STRUCTURAL ENGINEER; Assoc. M. Am. Soc. C.E.; technical graduate; over 15 years experience on steel, concrete, and frame buildings, heavy foundations, and industrial planning. For 10 years as engineer-in-charge with consulting engineer. Desires responsible position with engineer, architect, or contractor, in office or field. D-3299.

ENGINEERING EXECUTIVE; M. Am. Soc. C.E.; Pennsylvania license. Experienced administrator, general engineering and construction projects (foreign experience). Consulting engineer, specialized, foundations, and port and terminal works. Interested in the administration of engineering projects from design to operation, also in making investigations, surveys, and reports on commercial and engineering projects, United States or foreign countries. D-3268.

GRADUATE CIVIL ENGINEER; M. Am. Soc. C.E.; Rensselaer Polytechnic Institute; wide experience in designing, fabricating, and selling structural steel; desires position to sell such or machinery. Is a member of national engineering societies and has many acquaintances among contractors and engineers. Has a comprehensive knowledge of engineering, sales, and contracts. Mid-Eastern or Southern territory preferred. C-7790.

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; 10 years in the United States; graduate in business management. Now resident abroad with finest connections. Receptive to negotiations for association with American concern wishing representation in the Scandinavian countries. Investigations, reports, translations, advertising, research. C-5983.

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; long experience, draftsman, chief of survey party, and engineer in land surveying and topography and in drainage, flood control, water supply, sewage, and railroad engineering. U. S. Civil Service status. Prefers vicinity of Washington, D.C., but would consider another locality. A-5125.

ENGINEER SUPERVISOR; M. Am. Soc. C.E.; 47; married; registered in Pennsylvania. For over 20 years engaged in the supervision of engineering, sales, and operations of fabricating business. Exceptional record but handicapped by present depression. Looking forward to favorable possibilities at present indication of big business revival. Invite correspondence. C-5095.

STRUCTURAL ENGINEER; Assoc. M. Am. Soc. C.E.; 40; single; graduate of Massachusetts Institute of Technology; 12 years experience in detailing, designing, estimating, and erecting structural steel and reinforced concrete for mill buildings, airplane hangars, office buildings, hospitals, apartments, bins, towers, railway bridges. Location preference secondary; available on short notice. D-3344.

GRADUATE ENGINEER; Assoc. M. Am. Soc. C.E.; Massachusetts Institute of Technology, 1921; 36; married. Experience: sales, tests, and reports, machine and construction designs, estimating, supervision, purchasing, and specifications. Writes and speaks French fluently. Conscientious and ambitious man available on short notice for responsible position. B-5822.

GRADUATE CIVIL ENGINEER; 1922; Jun. Am. Soc. C.E.; 30; 3 years construction experience; 7 years as engineer in technical department of two cement companies. Duties consisted of consultation with customers, cooperation with engineers and architects on concrete problems, promotion of products, design of mixtures for ready-mix concrete, and office correspondence. C-370.

ENGINEER; Assoc. M. Am. Soc. C.E.; experienced in design, fabrication, shop practice, and coat analysis of stuctures fabricated of high-tensile stainless steel. Familiar with researches in welding processes and development of new uses for products in design of trains, trucks, buildings, and bridges. Can organize shop and engineering force and furnish sales contacts. B-3113.

SANITARY ENGINEER; M. Am. Soc. C.E.; A.B. and C.E. degrees; 17 years experience in design, construction, and operation of water-purification plants and sewage-treatment works. Good experience in swimming-pool sanitation. Detailed experience supplied upon request. Desires position with consulting engineer. D-3357.

JUNIOR

JUNIOR CIVIL ENGINEER; Jun. Am. Soc. C.E.; desires any engineering work, location immaterial; 26; married; B.S. in C.E., Ohio Northern University, 1929; 3 months highway engineering; 5 years experience fabrication and tempering strong aluminum sheet and plate. D-3309.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; 23; single; B.S. in C.E., Rutgers University, 1933. Majored in structural design and hydraulics; 9 months rod and chainman; 3 months, chief of topographical field party; resourceful, dependable. Desires engineering position where ability and willingness to work will count. Salary and location open. Available immediately. D-3316.

CIVIL ENGINEER; Jun. Am. Soc. C.E., B.S. in C.E., University of Minnesota, 1933. High scholastic record; earned own education; drafting experience; accurate, adaptable, and some mechanical ability; no engineering experience; 25; good health. Salary in proportion to responsibility of the work; available on two weeks notice. D-3327.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; graduate, 1927; married; 28. Varied experience, including surveys, design, and construction. Party chief on surveys; in charge of construction of highway bridges; 2 years design work on large hydro-electric plant; structural steel fabrication. Available on one month's notice. D-3329.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; 24; single; B.S. in C.E., Rhode Island State College, 1932; 3 months experience in U. S. Coast and Geodetic Survey; some experience in architectural design and construction; neat and accurate draftsman. Desires opportunity in any branch of civil engineering; would prefer building design and construction. Location immaterial. D-3335.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; 22; single; B.S. in C.E.; Newark College of Engineering; 1 year as assistant in civil engineering office; 1 year as physics instructor; 6 months as supervisor of Motor Vehicle Traffic Survey. Desires opportunity in any branch of civil engineering. Location secondary. D-2960.

GRADUATE CIVIL ENGINEER; Jun. Am. Soc. C.E.; 24; single; C.E. and B.S., College of the City of New York, 1932; field instructor in surveying; draftsman. Desires work on construction or in surveying. Location immaterial. D-2851.